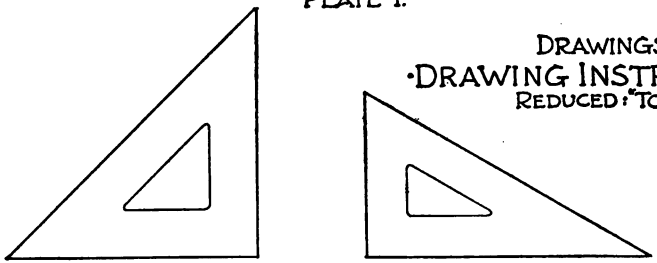
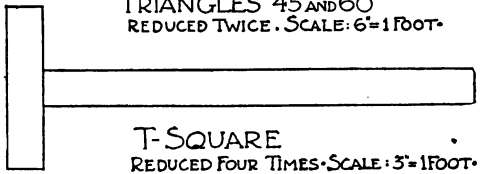
A Primer of Architectural Drawing

PLATE 1.

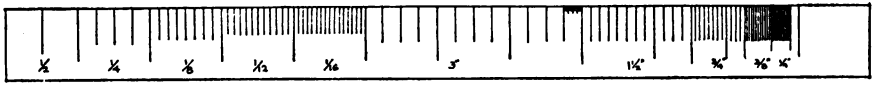
DRAWINGS OF DRAWING INSTRUMENTS REDUCED TO SCALE.



TRIANGLES 45° AND 60°
REDUCED TWICE. SCALE: 6" = 1 FOOT.



T-SQUARE
REDUCED FOUR TIMES. SCALE: 3" = 1 FOOT.



ONE FOOT RULE
ACTUAL SIZE: FULL SIZE.

A PRIMER OF
Architectural Drawing

FOR YOUNG STUDENTS

BEING A PROGRESSIVE SERIES OF DRAWING BOARD PROBLEMS, THE EMBODIMENT OF THE AUTHOR'S TEACHINGS IN THE MECHANICS' INSTITUTE OF NEW YORK CITY

BY

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1910

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PREFACE

In the creating of this little book, thousands of hours of thinking and planning, observing and experimenting have been spent. The work, if such it may be called, has been almost wholly a delightful one, and has been in itself an inestimable reward to the writer.

For the idea of writing the book, as well as for inspiration and encouragement during its progress, the author is indebted to Mr. Louis Rouillion, principal of the Mechanic's Institute of New York City. He is indebted also largely to the opportunity afforded him, by his connection during five years with this school, of putting his ideas into actual practice and of testing his theories from day to day.

He is indebted to Richey, Browne and Donald Iron Works for the working details of one of his large plates.

To the hundreds of students whom the author has met in the past, as well as to those whom he may not meet, he trusts that this book may be a means to guide them safely through the earlier and more fundamental problems in architectural drawing, and thus prepare a strong, and at the same time, inspiring foundation for the more advanced problems in architectural planning and design.

WM. S. B. DANA.

Grantwood, New Jersey.
June 1st, 1910.

INTRODUCTION

We are to study in this book how buildings are made, as well as the drawings of all their various parts. And suppose that we first, by a feat of the imagination, gather all the buildings of the world in pieces into a great mountainous heap, with their millions of tons of bricks, millions upon millions of tons of stone, marble, and tiles, and forests of sawed timbers and boards; iron and steel and the other metals in all known shapes, from tacks, screws, nails and bolts, up to the steel columns and girders of giant buildings; the sheet tin of roofs, galvanized iron of cornices; the pipes, fixtures and fittings of buildings; the glass, plaster, mortar and all the vast multitude of forms and shapes and materials which, joined together, make up the great army of the world's buildings; blocks from the Pyramids and the Coliseum, the majestic columns of Greece, vaults from the cathedrals of France and Germany, elaborate roof trusses from the churches of England and all the wealth of ornament in marble and other beautiful stones; and with these, mingle the hewn sides of the caves of the cave-dwellers, and the mounds of the Esquimaux. Among this multitude of forms, there are some which we must know and understand more particularly than the others, owing to their greater importance. If we look closely, we will find that the common brick is a little over 2 inches thick; twice as wide as it is thick; and twice as long as wide. We will have to know that it is made with six faces, perfectly smooth and straight, and that when it is placed on its flat side in a wall, its four smaller faces—the narrow ones—are vertical; that blocks of cut stone are of the same shape, though their inner face, which is hidden, is very often left rough; that the beams and boards are cut (sawed) in the same way, so as to have four long sides, and two ends, but owing to the fact that they are cut from trees, they are of much greater length than bricks or stones; yet their common form

is the same; that the sheets of window glass or plate glass have six faces, two being quite wide and flat, while the other four are very narrow, thin edges; and that finally, the paper and cloth used on the interior of walls as also the roofing, iron plate, etc., are of this same general shape.

Nature was the first builder so we may look to her works to see the origin of the floor, wall and roof which are what constitute all buildings.

In the trees of the woods we see the first walls. Rooted firmly in the earth like any foundation, they rise step by step into the air like the shafts of temples. As with all walls, their power of resistance to pressure from any direction is great. In our wooden houses, these same trees do their work as corner posts, studs and joists.

Stone walls, too, occur, as we may see, in steep cliffs and mountain-sides, their faces offering a continuous surface of resistance, somewhat like the brick walls of cities.

In the ground itself we see the first floor. The roof we may imagine as suggested in the branches of the trees.

Now, if to the base of two trees, a plank may be supposed to be nailed, and above this a second plank, a third, and so on until a height of seven or eight feet is reached, we have plainly constructed a rough wall. If a second such wall were made a short distance away, but a little higher, and a row of planks were laid on top, stretching across from wall to wall, we will have constructed a simple roof. For our floor we have the ground. If our two walls were carried up the same distance further, the plank roof would become a floor—a floor with a span as in actual buildings. Enclose the remaining two sides of our space below, and we have a building, though still a crude one.

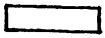
Cover the ground floor with blocks of stone, fitted tightly together, or bricks, planks or other hard material, and it will be greatly improved for living purposes. Examples of the hardening or reinforcing of city streets may be thought of in this connection, such as basalt block paving, asphalt, wood-block paving, etc.

To make our shell habitable, however, portions of the planks in the walls would have to be removed to provide openings for entrance, light and air; as is also the case with the roof where

it might be necessary for a pipe or chimney to pass through, or perhaps a ladder for passage to the roof (or floor) above. Our structure now may be said to be a box, of larger form, whose sides are stiff sheets, some on edge, some flat and some more or less slanted; a box not for folding goods only, but for men, women and children, and sometimes animals, to live in.

If our trees had been sawed off at a height of say ten feet, and other tree trunks been laid across on top of them and spiked to them, a rough building frame would have been the result, typical of all building frames whether of wood or iron. The smaller structures in houses such as chairs, bureaus and other furniture, have the same form; they are all frames. Many of them are virtually boxes with doors and wheels (casters) attached to them for moving them about. These latter suggest the great family of vehicles which, from the cab and motor car to the trolley car and railroad car, are simply boxes on wheels, each having its four sides, top and bottom.

In the case of small stationary compartments, telephone booths offer simple examples of boxes. The booth becomes a room when it is needed to house several people, which gradually increases in size to a small collection of rooms, or a cottage, finally reaching its full development in a department store or office building. Still boxes—but boxes of a larger mould with their perpendicular sheets grown more immense, and their horizontal shelves vaster in extent.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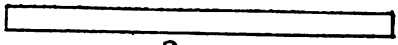
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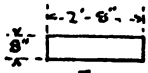

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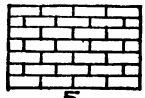
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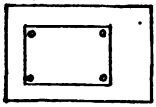
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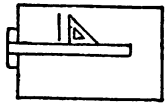
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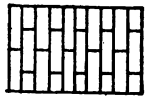
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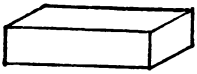
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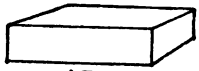
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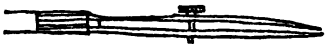
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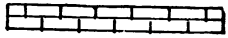
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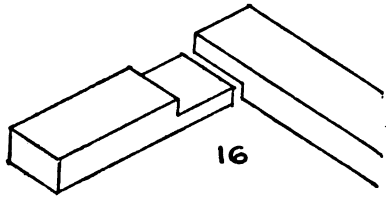
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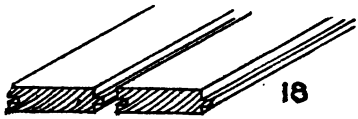
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FOREWORD

To start our work the following instruments are necessary. These will suffice for the complete mastery of all the problems in this book. A 20"x 26" Drawing Board; 7" 45 degree Triangle; 8" 30 degree—60 degree Triangle; 26" T-Square; a case of good Drawing Instruments including Ruling Pen, Compasses and Dividers; some good drawing pencils letter H. or No. 3; good pencil and ink erasers; a large sponge eraser for cleaning; a box of thumb tacks; a bottle of good waterproof drawing ink; two dozen sheets of stiff brown or white drawing paper 11"x 15"; one dozen sheets of strong white drawing paper 15"x 22".

As we have seen in our introduction, the majority of all building forms have six faces, and in making a drawing of one of these forms, we really make a *"pattern,"* on drawing paper of one or more of these six faces. The exact outline of the outside face of a brick (the other five being hidden within the wall) can be traced right on a piece of tracing paper, as in Fig. 1; or the upper face of a board in the floor as in Fig. 2 (the other five are hidden), or the upright face of a door, the other sides being hidden. And as this is true of a single brick in a wall, or a single board in a floor, so it is true of all the bricks in the wall, and all the boards in the floor, each of which in turn will be found to have six faces, just as have the sheets of glass or paper or metal. If a tracing also of the top face of the brick and one of the end were made, these three drawings together would give the exact size of the brick, as the other three faces are exactly the same as the three just shown.

Let us say that upon measuring the outline of the brick on our tracing paper, we find the long edges to be just 8" long, and the short ones 2"; or, we would say the size of this face of the brick is 8" long by 2" wide; a rectangle. Now suppose that we wish to make a drawing of the face of a block of stone whose

long edges are just four times as long as the edges of the brick; and whose short edges are four times as long as the short edges of the brick. To make a long story short, we needn't make one; the one we already have is large enough to show the shape of the block of stone; all we need besides that is to tell what it is a drawing of, and that it is just ¼ as long and ¼ as wide as the object; or, that the face of the object is four times as long and four times as wide as the drawing; what then are the actual length and height of the face of the stone? Answer: Four times 8″, and 4 times 2″; or 32″ and 8″, marked as in Fig. 3; therefore, every 3″ on the drawing stands for 12″ on the object, and by finding out how many 3″ or parts of 3″ there are in the long side of the drawing, we can find how many feet and parts of a foot (inches) the object is long; the same with the width. Or, as a draughtsman says, the drawing is at a scale of 3″ to the foot; or, scale 3″=1 ft.

Now let us proceed at once to learn how to make buildings *on paper;* look first at our drawing board, an oblong board, like a bread board or the top of a table (its top is also an oblong) its edges being two pairs of straight lines. Look at our sheet of drawing paper; the same shape only smaller, and meant to be tacked to the board with thumb-tacks at the corners as shown in Fig. 6. Notice that four of the lines in this cut run straight up and down, that is, *vertically,* and the other four straight from left to right, or *horizontally.* One set are *vertical* lines, the other, *horizontal.* Learn these two names. Fit the T-square with its "head" against the left side of the board. When placed as in Fig. 7, the "blade" runs horizontally across the sheet, and a line drawn by a pencil along its *upper* edge will be a horizontal line. A "triangle" placed as shown in the cut will have one edge so that a line drawn along it will be a vertical line. The other edge makes an "angle" of either 45°, 60°, or 30°, according to the slant. Which of your instruments is the T-square? The 45° triangle (with two straight sides equal)? The 30°-60° triangle? We have talked thus much about these two kinds of lines, the vertical and horizontal lines, because almost all the lines in buildings are one or the other. Horizontal lines should always be drawn along the upper edge of the T-square from *left* to *right;* vertical lines from below upward along the edge of a triangle, as shown in the cut.

PROBLEM I

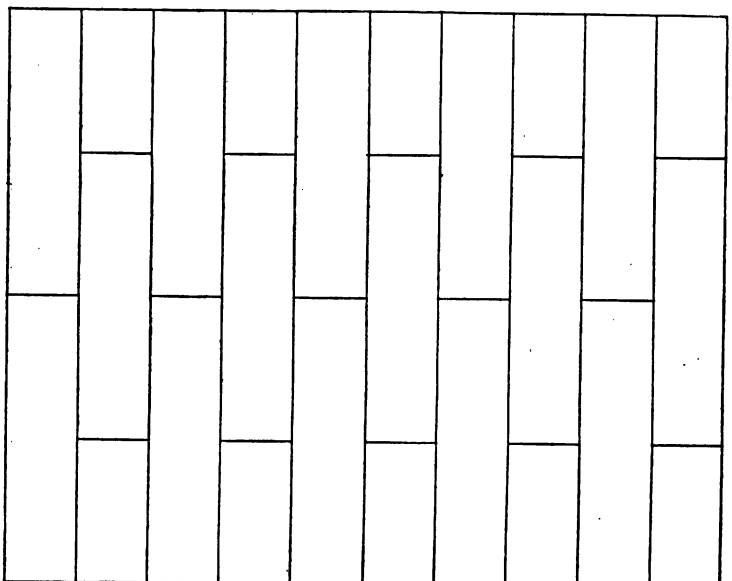
(See Plate 1)

Tack a sheet of drawing paper, 11″x 15″ (11 inches wide by 15 inches long) in a horizontal position on your drawing board; that is, so that it will be longest from left to right. Draw with your T-square a line across your sheet, ⅛″ below the top edge, and one ⅜″ below this again. ⅛″ and ⅜″ above the bottom edge, draw similar lines.

Along the left edge of the sheet draw with your triangle a vertical line, ⅛″ from the edge, upward to meet the ⅛″ line across the top of the sheet, and joining the ⅛″ line at the bottom. Draw also a vertical line ½″ from this. At the right edge, draw similar lines. The tacks should always be placed at the corners between the ⅛″ line and the edge. The first exercise is to draw from a point 6″ from the left border line and 4″ below the top one, a vertical line upward 3½″. From its lower end, draw a horizontal line 3½″ to the left. Connect the ends of these two lines with a slanting line. If this drawing represents your 45° triangle, at one-half size, what is the actual length of its two equal sides? Answer: 3½″ multiplied by 2=7″. If the width of the three sides is 1¼″, what will the drawing of them be if reduced ½″? Answer: 5/4 ÷ 2=⅝″. Draw the sides this width.

At a distance of 1½″ to the right of this view, draw the view of your 30°-60° triangle, reduced also one-half. ½″ below these views draw in plain, square capital letters, 3/16″ high, the words, "Triangles 45° and 60°" and so forth, as shown on the plate. Make smaller letters, ⅛″ wide, ruling a light horizontal line for their upper and lower edges. 1½″ below these triangles, draw carefully the top view of your T-square laid flat. Draw the title as shown on the plate. 1½″ below this, draw a one-foot rule, dividing carefully the inches as shown. Letter the title also as shown. Draw the title in the upper right hand corner, and at the top of the sheet, the plate number. Trim off the sheet on the ⅛″ line.

PLATE 2.



TOP VIEW OF
PART OF BRICK FLOOR
½ SIZE • SCALE: 6"-1FT.

PROBLEM II

(See Plate 2)

Tack a sheet of brown or white drawing paper, 11″x 15″ so that it will be about in the middle of your board, near the left edge, and having its length from left to right. The upper edge must be exactly in line with the edge of the T-square. Draw ½″ down from the upper edge a horizontal line across the sheet; also one ½″ above the lower edge. At the right hand edge draw a vertical line at the same distance from the edge, and one at the left edge ½″ from it. For a "cutting line," draw a line ¼″ from the edge all around. Now, inside these lines, draw a horizontal rectangle (or oblong) 10″ long and 8″ wide, so that the upper line is 1″ from the border line, and the left hand edge is 2″ from the left border line (not the cutting line). Then draw vertical lines across the rectangle so as to make ten equal spaces, each an inch wide. The first one at the left, divide into two spaces, four inches long, by a horizontal line across the middle. Divide also the third, fifth, seventh and ninth spaces in the same way. Divide the second space into three spaces by horizontal lines drawn as in Fig. 8, so that the middle space will be the same size as each of those in space No. 1. Divide spaces Nos. 4, 6, 8, and 10, in the same way as space No. 2. ¼″ below the top border line, near the middle, draw a horizontal line about 2″ long, below this 3/16″, another.

Between these two lines print with the greatest care "Plate 2," making the capital letter 1/16″ higher than the others. Leaving a space 3/16″ below the drawing, rule two horizontal lines 3/16″ apart, lightly, about 2″ long. With these for guide lines, print near the middle the words "Top View of"; then leave ⅛″ space; then draw two more horizontal lines 3/16″ apart; draw the words "Part of Brick Floor." Leave a space of ⅛″ again below the last two lines, and draw two horizontal lines ⅛″ apart. Between these lines draw the words "½ Size: Scale 6″=1 Ft." Note that this completes a *line drawing* of the top

face of a number of bricks. It is a measured drawing in which only one of the six sides of the floor is shown. Where the sides are shown just as they appear in reality, as in Fig. 9, or Fig. 10, that is, with three sides showing, the drawings are called isometric (Fig. 9), and perspective (Fig. 10); isometric, where the slanting lines are all at the same angle (30° in this case), and perspective where, as in Fig. 10, the three slanting lines are not at the same angle. But the method of our drawing in which only one face is shown at a time, whether reduced twice, four times, eight, sixteen, or any number of times, is called the method of Projection.

Note that our drawing shows merely the shape, and position of our objects. They may also be colored if necessary. But the actual bricks in the floor must be chosen from samples, a description of which, in words, may accompany the drawing.

Next tack tightly over your drawing a sheet of architects' tracing paper. Then filling your ruling pen, with the filler, with India ink, (see Fig 11), trace carefully on the paper the lines of the drawing beneath; also all lettering. Letter "Plate 2A."

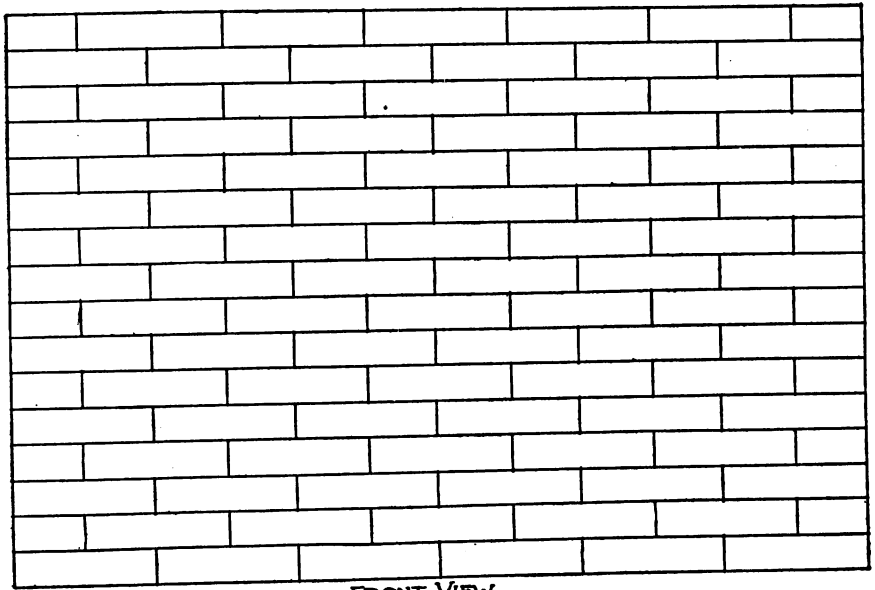
PROBLEM III

(See Plate 3)

Tack a fresh sheet of drawing paper on your board just as before. Draw the border lines first. Next, draw a horizontal rectangle 12″ long and 8″ wide, so that its upper side is 1″ from the upper border line, and the left side is 1″ from the left border line. Then draw horizontal lines across it, dividing it into 16 equal horizontal spaces, each ½″ wide. Divide the lower horizontal space into 6 spaces, each ½″ high by 2″ long. Divide spaces 3, 5, 7, etc., in the same way. Divide spaces 2 and 4, 6, 8, etc., so that there will be a space at each end 1″ wide, and the other five spaces 2″ wide as in Fig. 12. Draw carefully the title beneath as in the last plate, "Front View of Brick Wall." Below there may be drawn between lines ⅛″ apart, "¼ Actual Size: Scale 3″=1 Ft."

Tack tracing paper over the drawing, and using a very soft, though sharp, pencil, trace the same, line for line. Mark these plates "Plate 3" and "3A," in the same place as on the first plate. Letter carefully your name in the lower right hand corner, and the date in the lower left hand corner.

PLATE 3.



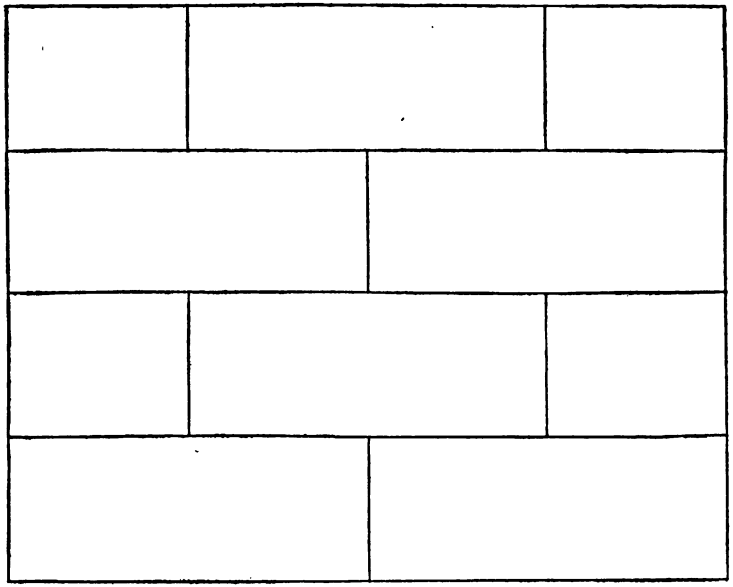
FRONT VIEW
OF BRICK WALL

PROBLEM IV

(See Plate 4)

Tack down your sheet and draw the border lines as before. Draw a horizontal rectangle the same as Plate 2, 10″ long by 8″ wide. Divide it into four horizontal spaces each 2″ wide. Divide the lowest space into two spaces each 5″ long, by a vertical line down through the middle of it. Divide the third space in the same way. Divide horizontal space No. 2 into a space 2½″ wide at each end, thus leaving a space in the middle 5″ wide. Divide the top row in the same way. Letter the name "Stone Wall," and in addition, draw a row of letters beneath this, "Scale 3″=1 Ft.," in letters ⅜″ high. Letter your name and the date. If the blocks in the lower row had been 3″ high instead of 2″, on paper, at the scale of 3″=1 ft., how high would the blocks themselves be? Answer: One foot. As in the drawing they are 2″ high, the blocks themselves will be only ⅔ as high, or ⅔ of one foot, or ⅔ of 12″=8″. By the same method, how long are the blocks? Answer: 1′-8″. If the drawing remains just the same, but the scale is only 1½″=1 ft., will the blocks be larger or smaller? Answer: Larger: twice as large.

PLATE 4.



STONE WALL.

PROBLEM V

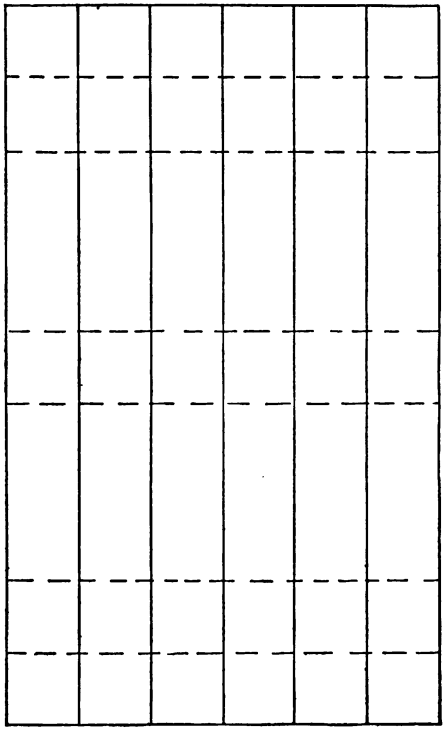
(See Plate 5)

Keeping your drawing board in the same position, that is, longest from left to right, tack a new sheet so that it shall be longest up and down. Draw border lines as before, with $\frac{1}{2}''$ border line at the top. Draw a vertical rectangle 6″x 10″ whose top side shall be 2″ from the upper border line, and which shall be exactly in the middle of the sheet from left to right. Next, divide the rectangle into six equal vertical rectangles each 1″ wide. Draw the title beneath this: "Top View. Plank Floor": "Scale 1″=1 Ft.," may be printed below. How wide is the floor itself? How long?

If the title of this drawing were to be changed to "Front View of Portion of Board Wall: Scale 2″=1 Ft.," what position would the boards be in? What size would they be? If the drawing board were to be turned around to the left, so that the left side becomes the lower side, the drawing would become that of the "sheathing," or "rough boarding," or "clapboarding" of a wooden frame house. Return the board to its former position. Then, one inch down from the top edge of the drawing, draw a *dotted* horizontal line, 6″ long; then 1″ below this, a second dotted line. These two dotted lines represent the two edges of a plank which is under the long planks; they are nailed or spiked to it. Draw in the same way, another board at the same distance from the lower edge; also a third one midway between these two. The long planks, being firmly spiked to these cross ones, are held strongly together to make one big member, as, for instance, a platform, or, if stood on either edge and hinged at the sides to a post, a large gate. It might also be used as a sliding warehouse door or barn door.

A capital exercise in lettering at this point is to rule a number of horizontal lines $\frac{1}{8}''$ apart, and taking for a model the letters from some newspaper, magazine or book, or better, some good book on lettering, make a row of twenty or thirty of one

PLATE 5.

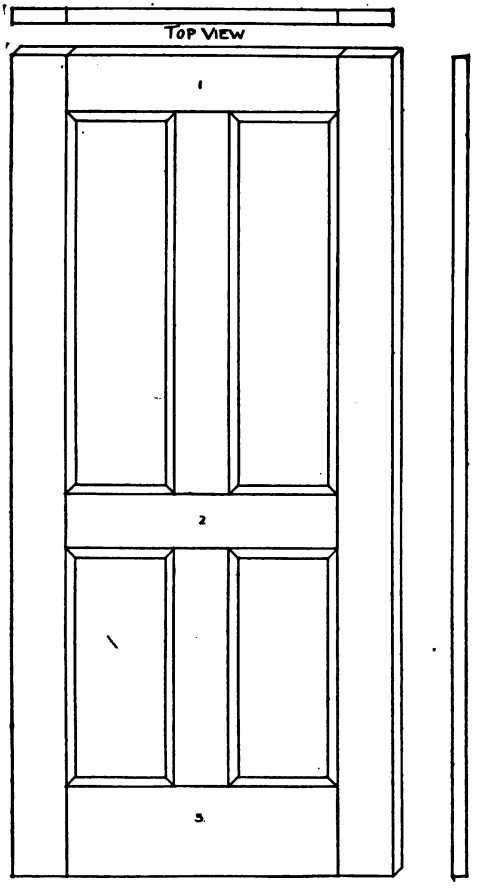


TOP VIEW PLANK FLOOR

letter at a time, aiming, of course, to make each letter better than the one before it. Plain, square, capital letters should be chosen. The letters and numbers are easiest studied in five groups, thus: 1. I L E F T H; 2. O Q C G S &; 3. D P B R U J; 4. V W M N Z Y X K A; 5. 0 6 9 8 3 5 2 7 4 1; the groups being called the I group; the O group; the third is a combination of the two; the fourth is the V group. In the numbers, the beginning one is zero. As the work must be done with a very fine pencil point (not a carpenter's pencil), it is necessary to keep it continually sharp; therefore, a sand-paper pad should be kept continually at hand. Again, the paper should be as clean when the drawing is finally completed, as when the sheet was first tacked down. Therefore, an eraser is always necessary.

To return to Plate 5. The drawing is the top view of six planks placed edge to edge and nailed to cross-pieces to form a platform: the *top view;* but it is continually necessary to make the side view of an object also. Let us imagine ourselves looking at this platform (it lies on the level ground) from the right side; the planks, all of them, are 2″ thick. We know without looking at it that the side view is just as long as the top view; no longer, no shorter. In other words it should be a rectangle 10″ long and 1/16″ wide. We know perfectly well that we would see the three ends of the cross-pieces, and just where we would see them. The top view with the side view beside it would appear as in Fig. 13. Now if we imagine ourselves looking at the platform from the *front edge*, it is perfectly clear that we shall see the ends of the six planks all in a row. The row will be just the same length as the platform is wide, and the thickness will be the same as in the side view. We will also see the edge of the cross-piece, which will be the same length as the row of ends. It is evident that the length of each plank end is just the same as the width of the plank in the top view. Therefore, the front view of the end of each plank will be exactly below the top view of it as in Fig. 14.

PLATE 6.



FRAMED DOOR

SIDE

PROBLEM VI

(See Plate 6)

Place a sheet vertically on the board. Draw the border lines. Draw at a distance of $2\frac{1}{2}''$ from the left border line a vertical rectangle $11\frac{1}{4}''$ long by $\frac{3}{4}''$ wide, its upper end $1\frac{1}{2}''$ below upper border line. $3\frac{3}{4}''$ to the right of this draw the same sized rectangle. Fitting between the sides of their upper ends, draw a horizontal rectangle $\frac{3}{4}''$ x $3\frac{3}{4}''$. Between their lower ends draw one $1\frac{1}{4}''$ wide by $3\frac{3}{4}''$ long. $3\frac{1}{4}''$ above the top line of this, draw the lower side of another horizontal rectangle the same length as the other and $\frac{3}{4}''$ wide. Number the cross ones 1, 2 and 3, beginning at the top. Between the sides of 1 and 2 draw a vertical rectangle $\frac{1}{4}''$ wide exactly in the middle; also one between 2 and 3. If the work has been done correctly our finished drawing is the front view of a *door* of which 1, 2 and 3 are "rails," the two outside verticals are "stiles," the middle uprights are "muntins"; the average thickness of these parts of a door is $1\frac{1}{2}''$. They are held together, "framed," by the ends of the rails being cut so as to fit into holes in the sides of the stiles. These ends are "tenons"; the holes, "mortises." The ends of the muntins are also fitted into holes in the sides of the rails; that is, they are "mortised and tenoned." The four spaces between the pieces are "panels," which are filled with thin sheets of wood, whose edges fit into grooves in the sides of the frame. The wood panels are also held in place by strips of wood about an inch thick, "mouldings," nailed around their edges. Lines drawn around inside of the panel lines, and $\frac{1}{8}''$ from them, will represent the mouldings.

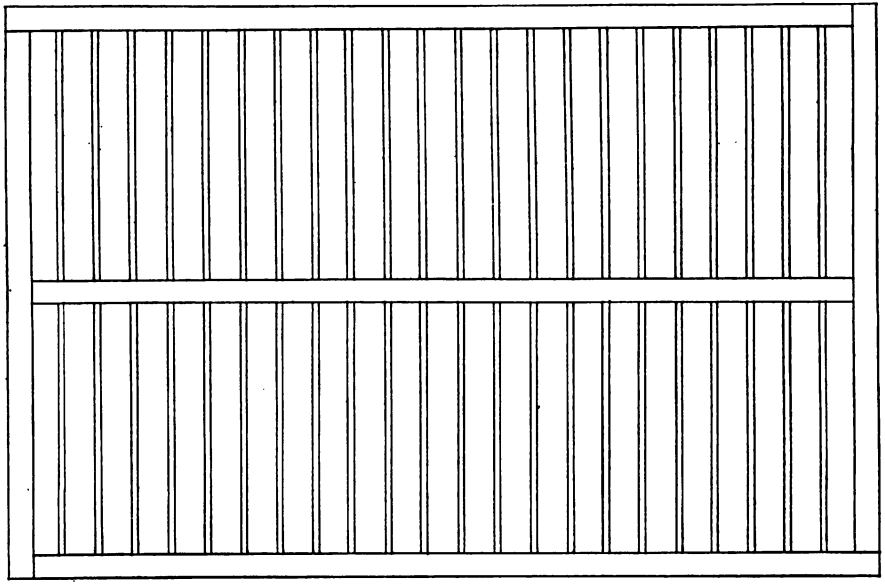
Now, the drawing of our door is $11\frac{1}{4}''$ high and nearly *half* as wide as high. But in order to find out from it what will be the actual height of the door itself, we must know how many inches on the drawing stand for a foot, that is, 12", on the door. This drawing has been planned so as to well fill our sheet, and we have found that the proper size for the door itself

would be 3′-6″ wide, by 7′-6″ high; or in inches, 42″ wide by 90″ high. Therefore, the drawing has been reduced 90÷11¼ times, or 8 times; also 42÷5¼=8 times. In other words each foot is reduced to ⅛th of its size, so that on the paper it is ⅛th of 12″ long, or 1½″ long. On your wooden scale you will find one edge divided into 1½″ lengths; and, again, one of these lengths divided into twelve parts, each one standing for an inch, although in reality they are only ⅛th of an inch long. It is very plain that if our drawing were to be that of the side of a house, it would be too large for our sheet unless reduced considerably more than eight times. In fact, it would have to be reduced six times more, that is, forty-eight times altogether, in order to make it fit the sheet. If a ⅛th reduction makes the foot 12÷8=1½″ long, then ⅛th of 1½″=⅛ of 3/2, or ¼″, which is the scale, or length of foot which is used in drawing nearly all walls and floors. Letter carefully "Framed Door" under drawing; "Scale 1½″=1 Ft.," should be added. Letter your name and the date. Before leaving this plate, draw from the two upper corners of the door, and from the lower right hand corner, a slanting line ⅛″ long upward to the right at an angle of 45°. The two top ones will join with a horizontal line. The upper and lower right hand ones will join with a long vertical line as shown on the plate. In this very simple way we have made our drawing look 50 per cent. more like a door, itself, by showing the thickness; thus converting our "projection" drawing into an "isometric" drawing as in Fig. 15. It is very clear what the side view would look like; a long narrow vertical rectangle, the same length as the front view, and 1½″ thick, at 1½″ scale. Find 1½″ on this scale. The top view, also, is very clear, being the same length as the width of the front view, and the same width as the side view. Draw these views, placing the top view (or plan) above the front view. Letter the name of each view.

The door, just drawn, is called a *framed* door. The four outside pieces make the frame; note how similar it is to the frame of a slate, of a fly screen, a picture frame, window frame, or sash. Make up a definition in your own mind of a frame, so that if any one were to ask you what it was, you could explain it at once. The reason why we must be so particular about this is that a great part of our work will have to do with just such

objects, some very large, some small, as the frame for the wall of a big wooden building, or the frame for a chair seat; also our work will have to do with huge frames of steel each of whose four sides, instead of being thin boards, consists of powerful columns, and girders of steel; or the frame of a small iron gate.

PLATE 7.



SIMPLE FLOOR FRAME.

PROBLEM VII

(See Plate 7)

Tack sheet, 11″x 15″, horizontally. Draw the border line. On a level piece of ground, four long wooden beams are placed so that they will enclose a large oblong space. Two of them, each 24′-0″ long are placed so that they are just 16′-0″ between their *outside* faces; they are 8″ wide and 6″ high, or thick. How long would they be on the drawing if ½″ represented a foot? Answer: 24 multiplied by ½″=12″. Draw one long beam from left to right across the sheet so that it will come within ⅛″ (actual) of the top border line. It will be a horizontal rectangle representing the top face of the long beam. Then 16′-0″ below the upper side of the rectangle, at ½″ scale, will be the lower side of the other long beam, the same size as the first. Fitting between their two ends will be two more 8″ beams. The method of joining the ends is very similar to that used in the pieces of the door, the ends being allowed to pass into notches in the sides of the long pieces, as in Fig. 16. Note that in this case, the hole or mortise is open and not entirely inside the piece, as in the door. Beams joined in this manner are said to be "halved." The joint is called an "end lap joint." Midway between the two long beams, show the top view of another 8″ beam connecting the sides of the short ones. Compare this drawing now with that of the door. Which pieces here correspond to the stiles? Answer: The 24′-0″ beams. The rails? Answer: The 16′-0″ beams. The "muntins"? Answer: The long middle beam. Which spaces are the panels? Answer: The two long spaces between the three long beams. Now, these spaces which in the case of the door were filled with thin pieces of wood, and, in windows, with glass, are here crossed by a number of beams 2″ thick, running parallel to the short sides of the frame; that is, vertically on the sheet. Beginning at the left hand end, the first beam is placed at a distance of 9″ from the inside of the beam. The next one is 10″, at ½″ scale,

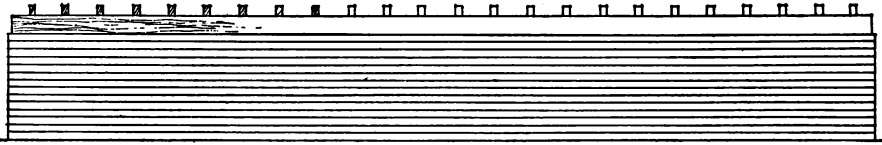
from the side of this, and all the rest are 10″ apart until the last space is reached at the right which is again 9″ wide. This gives a total of 23 spaces in each panel. Fig. 17 shows partly how the drawing will look. Remember that this is the drawing of the top face only, and in order to see the thickness of the beams we will have to make a front, or a side view. The 2″ beams which cross the two spaces are the same height as the frame to which they are nailed. Their upper and lower faces are "flush" with the upper and lower faces of the members of the frame; that is, they are neither higher nor lower, but on the same surface with them, their ends fitting into the sides of them (mortised and tenoned).

By simply laying boards cross-ways of the cross-pieces, edge to edge, we will make a *floor;* by nailing first one down (not through the top, but through the edge, so that the nail will be hidden), then nailing another tightly against it, and another, and another, and so on, we will have a very smooth and even floor; by using boards which have along one edge a groove, along the other a rim, or ledge, as in Fig. 18, we will have the very best flooring (tongued and grooved; matched); also called "ceiling," when used to make walls of. Very often another layer of boards is laid on top of the first to make a double floor. The under boards then make the "rough" flooring, and the upper the "finished" flooring. Our floor thus constructed and covered is strong enough for almost any load, especially if the ground which it is resting upon is hard, gravelly or stony, as every beam rests firmly on it. If it is marshy, then a very heavy load is likely to make it sink into the soil.

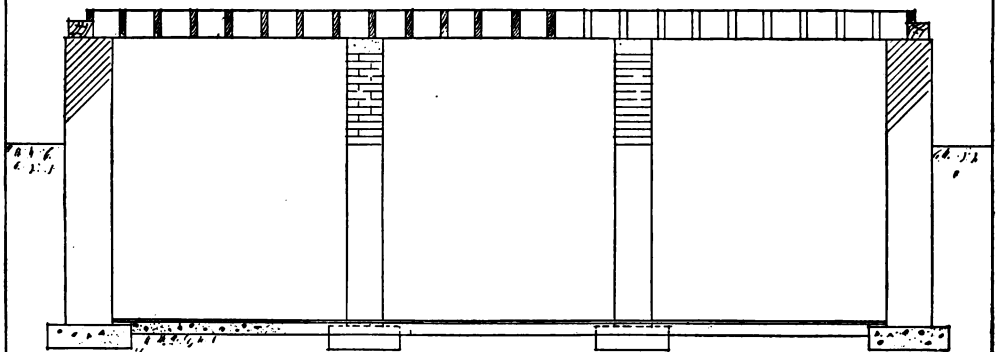
But our floor is not going to rest on the ground in any case, as brick or basalt rock floors do, but will be lifted a certain distance above it. The New Jersey Tenement House Act requires that floors shall be at least two feet above the ground on the under side; this is to make it easy for the air to be renewed and kept from getting unhealthy. It is clear then that the frame must be built on walls, its four outer edges resting on stone or brick walls. Sometimes instead of walls, posts or piers are used like the sawed off trunks of trees. Masonry piers or posts, would be used under the cross piece ("girder") of the floor frame. The outside members are the "sills"; the 2″ cross beams are the "floor joists." These names are very im-

portant, and should be learned at once. The walls which the floor must rest on must extend several feet into the ground, as we have seen. "Every building . . . shall have foundations of brick, stone . . . laid not less than four feet below the surface of the earth"—(New York Building Law). Under the New Jersey Tenement House Act, the ground under the floor must be covered with a floor of concrete. If this earth under the floor is excavated for a cellar, the walls would have to be carried down far enough, and with them the concrete floor, so as to give about eight feet of height between the cellar floor and the ceiling of the floor above. Light and air are provided to the cellar space through openings, or windows, in the walls, just above the ground. If wide stones are placed under the whole length of the foundation walls considerably wider than the walls (footings), the walls will be much less liable to sink or settle. But this we will talk about a little later under "Walls."

PLATE 8.



FRONT VIEW OF FLOOR FRAME
WITH FOUNDATION WALL
Scale ½" = 1 FOOT

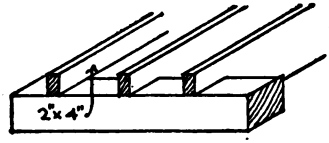


SECTION THROUGH FLOOR FRAME
SHOWING CELLAR

PROBLEM VIII

(See Plate 8)

As we have seen, the drawing of the floor frame in Plate 7 is not quite complete, as it shows only the top face, and not the *height* of the frame. Let us therefore imagine ourselves looking at the front edge of it. It is perfectly clear that all we will see is the front face of the 24'-0" beam, or sill, as everything else will be hidden behind this. The front view of the floor frame then will be that of a beam 24'-0" long and 6" high. Tack a sheet for Plate 8 horizontally on the board. Draw border lines; then 1" down from the top border line draw the front view of this beam at ½" scale. Refer to Plate 7 for a moment. Can we tell by looking at this drawing whether the tops of the 2" beams are above or below the tops of the sills? No: if they were 4" above the sill tops they would not show it on this drawing—but they would on the front view. Each beam end then would appear as a small rectangle 4" high and 2" wide resting directly on top of the long rectangle, and they will be just the same distance from the end of the sill and from each other as they are on the top view. These distances may be obtained exactly by laying a strip of paper along the beams in Plate 7, and marking them off on its edge. Then lay the strip on the front view, and mark off the dots exactly on it. Show in addition to these ends, the ends of a 2"x 4" piece resting along the top of the end sills as in Fig. 19, for the ends of the floor boards to rest on. Now the four sills of this floor frame may be supposed to rest, each of them, on top of a brick wall 16" thick; the outer edge of the sills being 1" inside of the outer face of the brick walls, as in Fig. 20. The top of this wall will be fourteen courses of brick, each 2¼" high, above the top of the ground, as shown. This height of wall, then, should be shown with the front view of the frame resting on top of it, as is shown on Plate 8. See also Fig. 21. Beneath this, as in the other plates draw, very neatly, the title "Front



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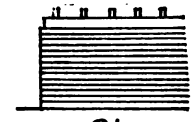

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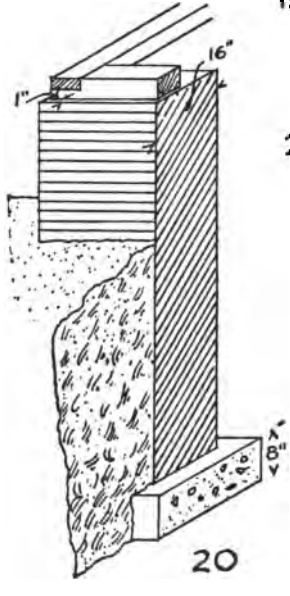

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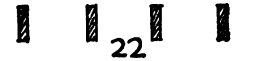

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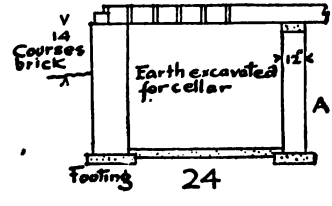

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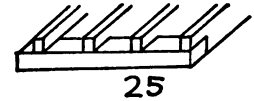

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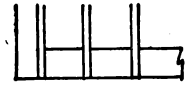

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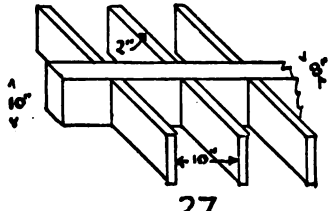

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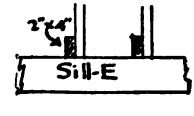


28

View of Floor Frame with Foundation Wall. Scale 1″=1 Foot."

Now this front view shows only a small portion of the ends of the 2″ joists; the greater part of each end is hidden behind the sill, and the only way in which we would be able to see the ends, would be by moving the sill away from in front of them, or better—and this is the way in which it is actually done—draw a very light line horizontally across your top view (Plate 7), crossing all the floor joists in the nearer row, as well as the end sills. This represents the path which a saw would make if it were passed through the frame from one end to the other. It would divide the frame into two parts. Imagine the near part removed; this would leave exposed the long row of sawed ends, as in Fig. 22, the same distance apart as in the top view and front view. Fig. 23 shows how it would appear at the left hand end. The two horizontal lines represent the side of the girder, to which the further ends of the beams are joined. Now a drawing of the sawed surface of an object is known as a "*section*," a drawing which is used to a very *great* extent in all mechanical and architectural drawing. 1½″ (actual) below our front view, draw this section showing the sawed ends of the beams directly below the front ends in the front view. Our saw will pass, not only through all the pieces of the frame (the sill at each end, and every floor joist), but through what they are resting on. We saw in Fig. 20 that each sill of the frame rested on top of a brick wall; one of the walls sawed through appears as in Fig. 24, the thickness being 16″, the height 8′-0″. Draw this section of brick wall under each sill section; each wall section again rests on the section of concrete, which runs around under all four walls; it is 8″ thick and 6″ wider than the wall on each side, like a step. A, in Fig. 24, shows a pier, the same height as the wall section; there should be two of these to support the heavy girder, and placed so as to make the three spaces, that is, between the brick walls and the piers, and the piers themselves, just the same. Draw carefully these two brick piers, showing the footings the same size as the wall footings. The top 5″ of the pier is stone. Dot the surface of the stone. Draw the courses of the brick below this, each 2½″ high. All the earth, of course, inside the walls is removed (excavated), all the way down to a level, just 3″ below the tops of the footings. The figure shows the sawed edge of a 4″

layer of concrete, placed entirely over the cellar bottom, with a 1″ thickness of cement on top of it. Show this clearly on the drawing. The feet of the piers and their footings, where they pass through these layers are hidden; so they must be dotted. The level of the ground on the outside of the foundation walls is 35″ below their tops; draw the top line of this as shown in Fig. 24. For a short space below this line draw a few short lines and dots to represent the earth. Letter the title for this, "Section Through Floor Frame, Showing Cellar."

PROBLEM IX

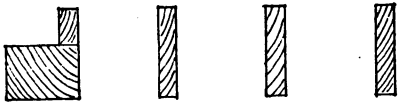
(See Plate 9)

The larger the scale, the more clearly the object may be shown; in fact, very often in architectural work, it is necessary to make a drawing the exact size of the object, ("full size drawing"). In order to show more clearly the way the sills in our floor frame join at the corners, as well as the joining of the cross pieces with the sill, let us make a drawing at 1½" scale, of the section of our floor frame at the left end, including the sill and three floor beams to the right of it; the under side of the sill should be 1½" (actual) below the top border line. Then 4" (actual) below this draw the under side of the sill, again, for a front view. Complete the front view, drawing its left end directly under the left end of the section. Remember that the lower half of the end is cut out to let the tenon of the end sill fit into it, as in Fig. 25. Show just the ends of four cross beams. Draw carefully also the slanting lines (isometric) making them 2½" long (actual) at an angle of 45°. The cut shows the ends extending all the way to the outer or front face of the sill. Note this very important point: That the drawing is first of all a front view, and then it is changed into an isometric view simply by drawing lines from the upper and right hand corners, with the single exception of the rear edge of the sill which is a horizontal line 4" (to scale) above the top sill line.

Next, just below the front view, draw the top view. This, of course, has nothing to do with the slanting lines of the isometric view. The top view (plan) should appear as in Fig. 26. Leave enough room under the front view so that the tops of the cross-beams will be 2½" long on the paper. Letter the drawing, "Top View."

To make clear how the cross-beams join the girder make a final drawing at the right of the sheet at 1½" scale and taken from Fig. 27. Make the slant 45° in the direction shown. In

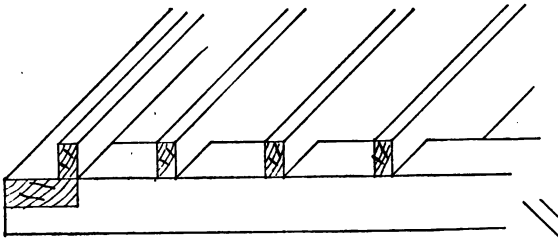
PLATE 9.



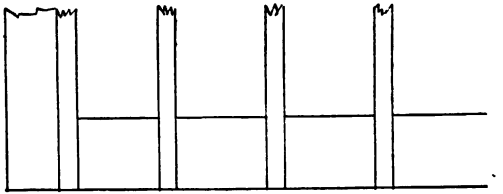
SECTION

VIEWS SHOWING FLOOR BEAMS JOINED TO FRAME TIMBERS

SCALE: 1½" = 1 FOOT.

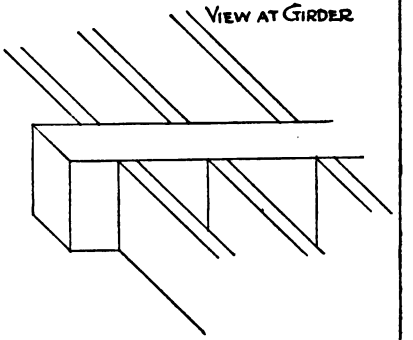


ISOMETRIC VIEW



TOP VIEW

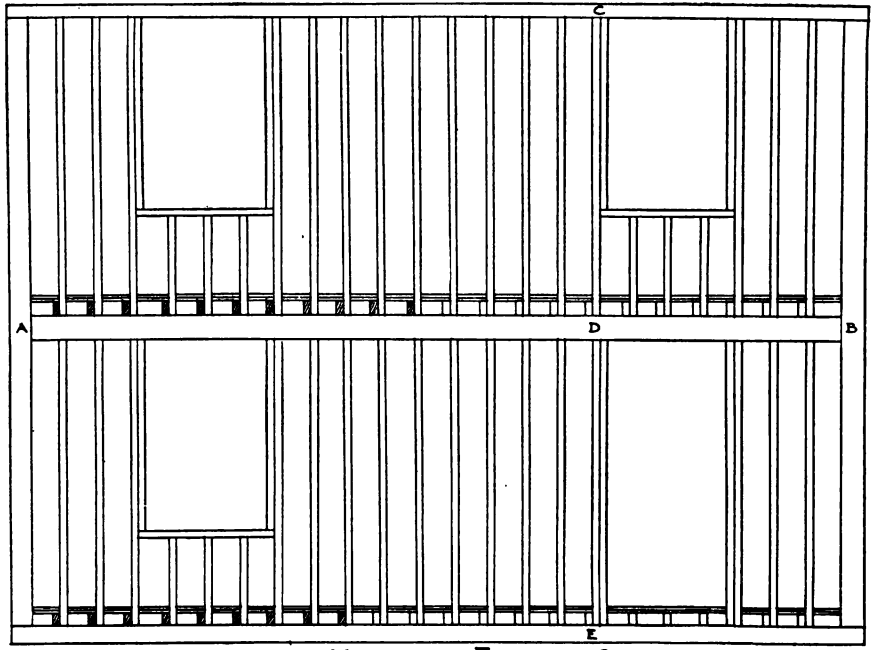
VIEW AT GIRDER



the remaining space at the upper right hand corner, letter the title for the sheet as shown on Plate 9.

In lettering, the capitals are always a little higher than the other letters. Do not fail to letter the title of each separate view; that is, for the front view at the top, the section, the combination large scale front view and isometric, the large scale top view (plan) and the isometric detail at the right of the sheet.

PLATE 10.



VIEW OF WALL FRAME WITH OPENINGS.

PROBLEM X

(See Plate 10)

Our next problem has to do with another large frame, outside measurement 24′-0″ from left to right, and 18′-0″ wide. Its size and shape are almost exactly the same as the last frame, except that the 24′-0″ beam at the bottom is 6″ wide, instead of 8″, and the one at the top only 4″. The scale is ½″=1 ft. The other point of difference is, however, the most important; that is, this frame, instead of lying flat, is *standing on edge.* There is an 8″ beam running through the middle from left to right, as in the floor frame, and the two long panels, or spaces are filled with 2″ vertical cross-beams as before. The frame in this position will be for a wooden *wall.* Thus far, the wall frame and the floor frame are the same. Of course, the cross-beams in the floor (joists) sometimes have to support very heavy loads, such as pianos, various kinds of heavy furniture, or a great many people; therefore, they must be much stronger than those which form the walls, for the reason that a beam of any kind which spans an open space is weaker than when it is in a vertical position. The 2″ beams (studs) in the wall frame are only 4″ wide, whereas in the floor frame they are 10″, or more, in width. Tack a sheet in a horizontal position. Draw the four outside pieces of the frame; first, the bottom one, or sill; then the two uprights at each end (corner posts) and the one across the top (plate) as well as the middle member (girt). We could draw the 2″ uprights in for the entire distance as in the floor, and then nail boards all over the outside face, and on the inside face put laths and plaster; this is just what is done when there are no openings of any kind to be left in the wall. But there are very few walls which do not have openings left in them for light and air. Almost every floor frame, too, has openings left in it. There is scarcely any floor that has not one or more good sized openings left in it for stairs to pass up through, elevators, dumb-waiters, chimneys, and in the case of

a flat roof, a scuttle. The openings in floors we will study later.

We have our wall frame, already. Let us mark the five members, thus: left hand corner post, A; right hand corner post, B; top cross-piece (plate), C; middle cross-piece (girt), D; bottom cross-piece (sill), E; letter the long upper space between C and D, F; the lower between D and E, G.

9″ to the right of A, at ½″ scale, make a point; 2″ to the right of this, another.

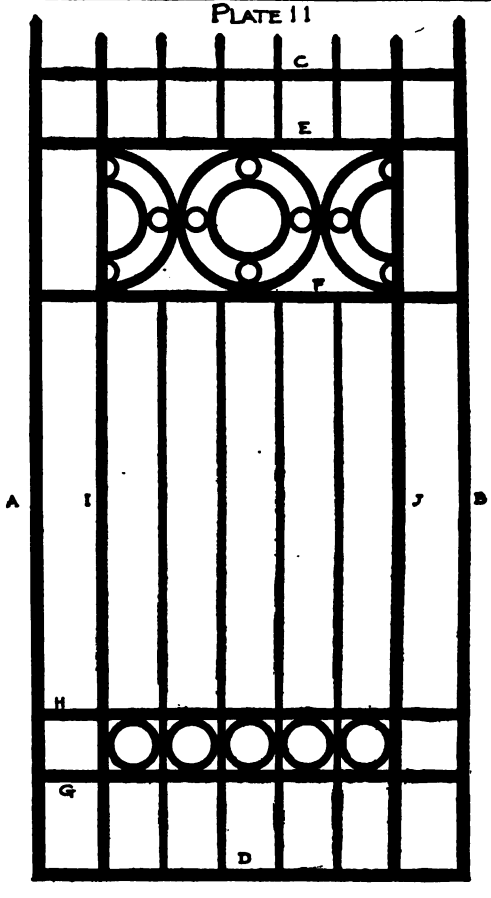
Through these points draw vertical lines across spaces F and G; they will represent the first studs. 12″ to the right of the right side of this first stud, make a dot; then make dots 12″ apart, beginning with this all the way across space F. 2″ to the left of each of these points, make another dot. Then through these points draw light vertical lines across F, and below them, across space G. The drawing now could not be distinguished from the floor frame which we made. In order to have openings for windows and a door, we will have to remove some of these studs. For instance, studs number 4, 5 and 6, counting from A, should be sawed off at a height of 2′-10″ above D in the upper space, and at a height of 2′-6″ above E in space G. On the tops of these three sawed-off studs is placed a 2″ cross-stud, running between the sides of the third and seventh studs. The upper portions of the sawed out studs should be erased.

At the right end of the frame, openings should be made at the same distance from B that the first ones were from A. The lower right hand opening, however, should have these studs entirely removed, as it is to be used as a doorway.

In the lower space, G, the ends of the studs are spiked to the sill E, and, at the top, to the girt, D. They are sometimes mortised and tenoned into the sill. The same is true of the upper row of studs. Then it is clear that not only are the studs supported by the heavy beams D and E, but the ends of the floor beams, also. Those resting on E, we have seen, are shown as in Fig. 28; and the studs, as shown are placed directly at the side of them. The upper row of floor beams are shown in just the same way, except that the whole of the end is shown, that is, 2″x 8″, as in Fig. 29. Draw in the beam ends. These floor beams are covered on top with a layer of 1″ boards

which are nailed to them, that is, the "rough flooring." Then very often another 1" layer is nailed down on top of these; this is the "finish flooring." Show the edges of these floors as in Fig. 30. Carry the flooring and beams across the bottom of the door opening. In order to strengthen the sides of the openings, show another stud next to the stud at each side on the inside of the opening. Letter the name of this drawing below it as shown; also the scale; and the number of the plate above.

PLATE 11



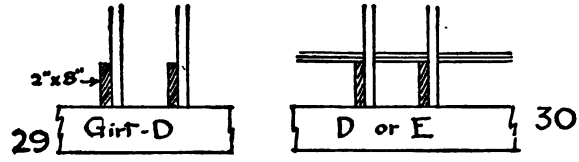
IRON RODS AND STRIPS FORMING GATE

PROBLEM XI

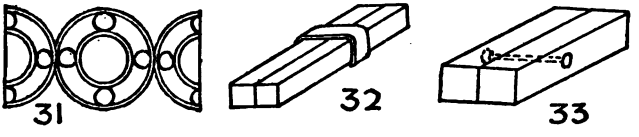
(See Plate 11)

We have seen how, by fitting wooden beams and boards together we have been able to make floors, walls, doors, etc. We are now going to learn how by fitting iron rods and strips together we can make a portion of a structure. For Plate 11, let us tack our sheet vertically. Draw the border lines; also a line vertically through the middle of the sheet. With this as a center line, draw the four sides of a rectangular iron frame whose outside dimensions are 4′-0″ wide by 7′-6″ high, scale 1½″ to the foot: the top side to be 1″ (actual) distance from the upper border line. The left side of the frame is made by a rod 1″ square and 7′-6″ long; mark this A. The right side is the same sized rod; mark it B. The top cross-piece, C, is 1″ square, running between the sides of A and B at the top; D is similarly placed at the bottom; 6″ below C show a cross-piece, E, 1″ thick, 3′-10″ long; 16″ below this show a similiar cross-piece, F, 1″ thick. 10″ above D draw same sized cross-piece, G. 6″ above this draw cross-piece H. 6″ to the right of A show upright I, running from C to D, and through cross-pieces G, H, F and E. Show a similar one to the left of B; mark it J. Divide the space between I and J into five equal vertical spaces, 6″ wide, by ½″ iron strips, running from top to bottom just the same as I and J, except that they do not cross the space between rods E and F.

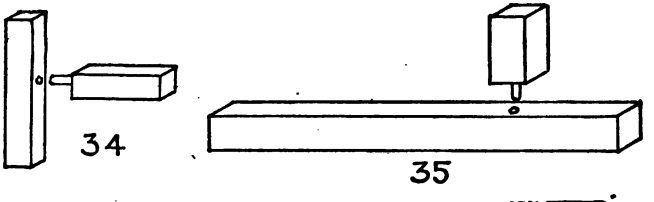
The space between G and H is divided into seven squares; the five middle ones are to be filled with circles made of iron strips ½″ thick, drawn with small compasses. The space between E and F, and bounded by I and J, is to be filled by a ring 16″ in diameter of ¾″ iron, in the middle; and by a half of the same sized circle at each end. In the middle of the main circle is a ring ¾″ thick and 9″ in diameter, outside measurement. The half rings will have half smaller rings inside of them. The inside rings and half rings are joined together by small rings



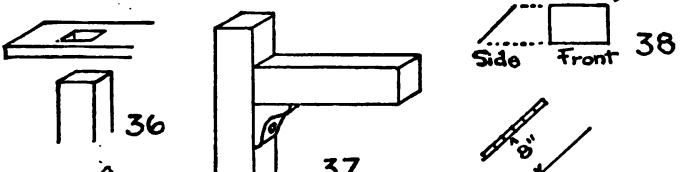
29 30



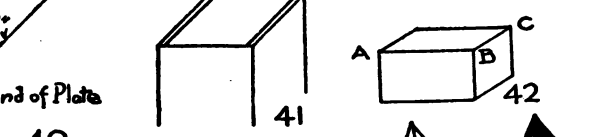
31 32 33



34 35



36 37 38 39 40 41 42



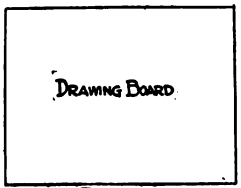
43 44 45 46 47

of $\frac{3}{8}$" metal, as in Fig. 31. Continue A and B 6" higher at the top; point them slightly. Continue all the other verticals 4" higher, pointing them slightly. Ink in solidly all rods, strips and rings with the greatest care. Under the drawing, letter the title carefully as shown. "Scale $1\frac{1}{2}$"=1 Ft.," may be added.

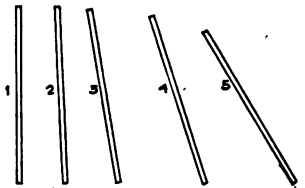
Our gate, as finished, *on paper,* holds together perfectly; but, it will be found not so easy to place the end of a real iron rod to the side of another iron rod, and expect it to hold fast. No; the end must be secured in a very particular way. Also, when they are placed side by side. Figs. 32 and 33 show two ways of binding together rods which are side by side.

Fig. 34 shows the end of one rod with a peg, or lug, on the end to fit into a hole in the side of an upright. This is also done in the case of the lower end of an upright resting on a cross-piece, as in Fig. 35. The lower ends of wooden studs in a wall are often treated in the same way. Figure 36 represents a smaller rod passing through a hole in a larger one. Fig. 37 shows another method.

PLATE 12.

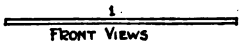


PLAN

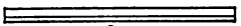


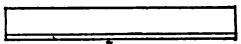
SIDE VIEWS

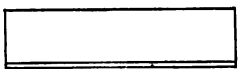
SCALE OF DRAWING BOARD
1½" = 1 FT.



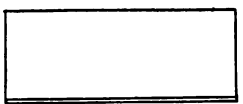
FRONT VIEWS

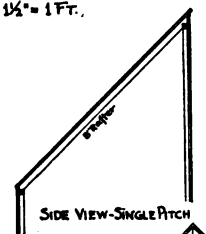






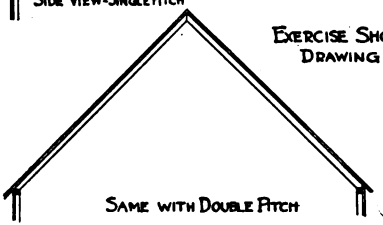
FRONT VIEWS



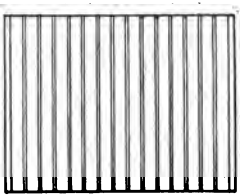


SIDE VIEW-SINGLE PITCH

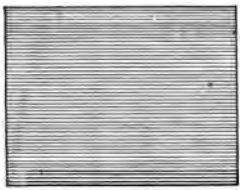
SCALE OF ROOFS · ⅛" = 1 FT.



SAME WITH DOUBLE PITCH



PLAN · SHOWING 2" RAFTERS



FRONT VIEW SHOWING BOARDS

EXERCISE SHOWING EVOLUTION FROM DRAWING BOARD, TILTED, TO ROOF.

PROBLEM XII

(See Plate 12)

Let us think for a moment what we have learned; we have learned not only how a wooden floor is made, its edges supported on walls; a wooden wall with openings for windows and doors; how the many parts are fastened tightly together; but we have also learned how to draw them, and that, *without seeing them.* That is, we know now how the two most important parts of *all buildings* are constructed and drawn. As we have seen before, there are three principal parts in all buildings—floors, walls and roofs; the roof, however, being in an almost endless number of cases, merely a floor more or less tipped or strange as it may seem, it may be really a slanting wall. The vaults of the great cathedrals are two opposite walls curved over at the top to meet each other over the middle of the space between them. But a slanting floor, or a tipped wall, cannot be drawn so easily as a flat floor, or a perpendicular wall, though our knowledge of how the latter are drawn will help use very greatly in the drawing of the roof.

Place sheet for Plate 12 horizontally on the board. Draw the usual border lines. In the upper left hand corner draw at 1½″ scale the top view of your drawing board, in a position longest from left to right; the top line should be ½″ (actual) from the top border line, the left line ½″ from the left border line; ¾″ (actual) below, draw the front view; that is, the front edge. ½″ (actual) to the right of the top view draw the side view; that is, the view of the right edge. Mark front and side views No. 1. ⅝″ (actual) below the front view, draw another front view in which, however, the further edge of the board is shown to be raised 1″ (draw this, of course, at 1½″ scale as before); mark it No. 2. ½″ (actual) to the right of side view, No. 1, draw side view of No. 2. Draw three more front and side views in which the further edge is raised 3″; 6″; and 10″ (to scale).

In the upper right hand corner draw a horizontal rectangle of the same size as the one in the left hand corner. ¾″ (actual) below this draw the same sized rectangle again. If the upper one represents the top view of the upper face of a board roof, or a tin roof which has a 45° slant, and the lower represents the front view, it is clear that if we look at this top face from the edge or side we will see a single line going up to the right at an angle of 45°, as in Fig. 38. Draw this side view.

Let us say that this slanting line represents the *edge* of the top face of fifty boards which are placed edge to edge like floor boards, making thus a slanting floor. The boards are 1″ thick; therefore the edge of their under face will be a line 1″ (to ⅛″ scale) below the upper edge. Draw this, and connect the two ends. One drawing is now a very thin rectangle. Divide this rectangle into fifty parts; each of these little parts will represent the end of a roof board. If the front view, next, is divided into fifty equal horizontal rectangles, we will have the front view of the fifty roof boards. The top view would be the same as the front view in this case, but we will not show the boards on it. In the side view, draw from the lower end of the upper line, a vertical line downward about ½″ (actual). Draw a vertical line also down from the upper end, 2¾″ (actual) in length. Draw vertical lines inside of these 1″ (to scale) from them These lines represent the edge of the *wall* boarding.

We have seen in the floor how the boards were laid on top of the 2″ beams; for the roof it is just the same; and by drawing a line in the side view 8″ below the lower line of boards, as in Fig. 39, the space between the two lines will represent the side view of one of the roof beams, or "rafters." This stands for all the others, too, because they are all in a row behind this front one, their upper edges and lower edges being at the same level as these. Draw vertical lines 4″ inside of the wall boarding of both walls, just as in the case of the wall frame, as in Fig. 40. Cross-hatch the wall boarding. The 4″ square at the top of the 4″ stud (that is, row of studs) is the end of the "plate." Show the end of the plate also at the top edge of the roof.

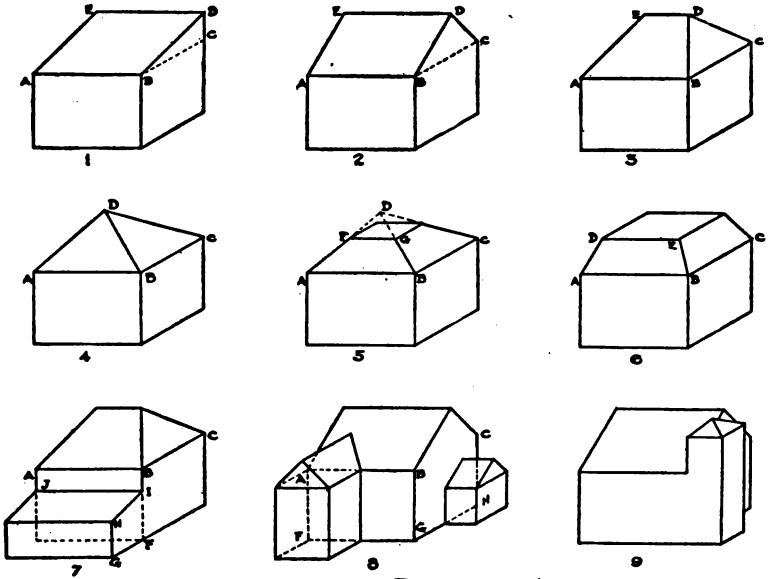
The number of rafters which is needed to make the roof must ordinarily be shown, of course, on the front view; also on the top view (plan). Show only on the top view, however. Draw a line 5″ inside of the end lines of the plan. This will

represent the inner surface of the wall studs which come up under the two ends of the roof—the slanting ends, as in Fig. 41. Next, divide the space between these inside lines into fifteen equal spaces by fourteen 2" beams (rafters) running from top to bottom.

Near the bottom of the sheet, and directly under the side view, draw a second side view the same as the first, omitting only the right hand wall. Then from the upper end of the top lines, draw downward to the right, at an angle of 45°, a line of the same length. Show the thickness of the boarding on both sides; also the 8" rafters; also the wall boarding with 4" studs. Where the rafters meet, at the top, is the "ridge"; where they join the walls at the bottom, the "eaves." Continue the roof boarding downward until it is 1'-0" beyond the outside face of the wall. Divide the two rafters where they meet, by a short vertical line. Cross-hatch the edges of the wall and roof boarding. This drawing now represents the gable end of a double pitched roof, or section. In the "single pitched" roof, our roof boards, not having been carried beyond the face of the wall, the water from rains will flow directly off the roof and down the face of the wall. The advantage, of course, of having a gutter at the eaves' edge is that the water does not fall in a stream to the ground, but is collected in the gutter and runs out through a pipe ("leader") to the ground. Put the title of every view, on the drawing. Also make a title in large letters for the sheet in the lower right hand corner.

Looking at the plate for a few moments, we will note that we began with a simple drawing of a drawing-board laid flat, making the three views: top, front and side. The next view represented the board, slightly tipped; this we may think of as resembling a flat roof, slightly graded to shed off rain-water; from this example, we worked up until the board was tipped to an angle of about 30°. Then we passed to the case of the top face of a board roof; then the front view of this top face; then the drawing of the edge of this face: the single line at an angle. Then we showed the lower edge of the boarding in the side, or edge, view 1" below, and the ends of fifty boards; then the rafters which supported the boards, and the wall at the top and bottom upon which the ends of the roof beams rested. We showed this also in the case of a "double-pitched" roof.

PLATE 13.



ROOFS AND THEIR EVOLUTION.

PROBLEM XIII

(See Plate 13)

To give you a clear idea of the many different kinds and shapes of roofs, the following plate has been planned. In it you will see a procession of roofs growing one out of the other. Plate 13 should be 11"x 15", tacked horizontally. After the border lines are drawn, draw very light horizontal guide lines, the first being 1¾" down from the top; the next 1" below this and then 1¾", 1", 1¾", 1", making three pairs of lines 1" apart. Light vertical lines should be drawn across the sheet as follows, at the following distances beginning at the left border line: 1¾", 1½", 2 5/16", 1½", 2 5/16", 1½", making three pairs of vertical lines 1½" apart. The three vertical pairs crossing the three horizontal pairs will make three rows of horizontal rectangles 1½"x 1", that is, nine all together. All lines are to be kept light.

Next, draw ⅞" to the right of each vertical row of rectangles a light vertical line. From the upper and lower corners of each right side of the rectangles draw a line slanting upward and to the right at an angle of 30°, until it meets the vertical line just drawn. Complete the isometric in each case, as in Fig. 42. Mark the rectangles 1, 2, 3, etc., from left to right.

From point B in No. 1, draw a line upward to the right, making an angle of 45° with the horizontal; draw a vertical line from C to meet it in point D. From point D draw a horizontal line to the left until it meets a similar 45° line drawn from A, in point E. Lines A B, B D, D E and A E as well as the vertical lines from A, B and D should be drawn in heavily, as well as the two lines connecting their lower ends. The result is the simplest form of a roof: a shed roof, or lean-to roof; this is also called a single pitch roof. Note that this roof is practically a floor slightly pitched, the front and rear walls being rectangles, one lower than the other, while the two end walls have their upper edges on the same slant as the roof slant.

From points A and B in No. 2, draw light lines up to the right at an angle of 60°. Draw a line from C up to the left at an angle of 45° to meet the line from B in point D; from D draw a horizontal line to the left to meet the line from A in point E. Draw in heavily A B, B D, C D, A E and D E; also the vertical and horizontal lines as in No. 1. Note that the building part is the same as in No. 1, and the roof part is very similar. The front part is the same except that it is a little steeper, and that it stops at just half the distance across, where it takes a slant downward to meet the other wall edge.

We might think of this as two sheds placed so that their higher roof edges come together. The name for this roof is "double pitched." It may be any slant whatever, depending upon the purpose for which the interior is to be used, or on the outside appearance desired. The ends of the roof, with the wall between them, are the "gables"; the edge where the two roofs meet, is the "ridge"; where the lower edge, A B, meets the wall, the "eaves." This is where the gutter is placed. Sometimes the eaves are carried several feet beyond the wall.

In No. 3, draw from point B a vertical line up, until it meets the horizontal line D E (of No. 2) continued to the right. From this meeting point, D, (No. 3) drew a line to C; also a horizontal line to the left until it meets a line from A drawn upward at 45° to the right, E. Draw the proper lines in heavily, as before.

This example, we might say, is the same as No. 2, only with the gables slanting in towards each other. Our building thus is covered with four roofs, one slanting up from each side. The two roofs at the ends are called "hip roofs," and the four edges where the roofs meet are the "hips," under which run the "hip rafters." This style of roof is very popular for country houses.

In No. 4, draw from point B a line up to the left at an angle of 60°, to a point just $\frac{1}{8}$" above A B measured in a straight line; letter this point D. From D draw straight lines to C and A. Roof B C D is almost the same as in No. 3, except that it is flatter and longer. The two upper points of the end roofs, instead of being separated by a ridge, come together in one point, making thus a "pyramid roof."

Draw No. 5 the same as No. 4, lightly. $\frac{1}{2}$" above A B draw

a short horizontal line connecting A D and B D; call this line F G. From F and G draw short lines up to the right at an angle of 30°. The one from G will meet C D; from this meeting point, draw a horizontal line back to the left to meet the 30° line from F. The portion D F G, etc., may be dotted, leaving a flat place on the top of the roof, or "deck." Generally a rail, or "balustrade," is placed around the edges of the deck.

No. 6 is very much like No. 5 except that its four roofs are very steep. Draw it thus: from A draw a line up to the right at an angle of 60° until it reaches a height of ½" measured vertically, directly above A B; mark the upper end, D. Draw the horizontal line D E, E being a point ⅛" to left of a vertical line drawn up from B. Connect B and E. From D and E draw lines up to the right at an angle of 30° until they meet a horizontal line extended from the point of the roof in No. 4. From the point where the line from E meets this horizontal line, draw a line to C. The flat part on the top, or "deck," is always slightly slanted to shed off the water. "Mansard" is the name for this roof. Note that the sides are really walls slightly tilted; and the top, or deck, is practically the same as we started with (No. 1), a flat roof. A projecting "cornice" or shelf, with mouldings underneath it, and with the top grooved for a trough, or gutter, is always placed along A B and B C. The flat roof is always sealed tight with metal sheets. Shingles are only suitable for pitched roofs where the water runs off quickly.

No. 7 should be made just the same as No. 3. Then from the corner of the wall 1" below B, draw a line down to the left at an angle of 30° a distance of ½"; from the end of it, draw a vertical line up ½" to point H; from this point draw a line up at an angle of 45° to the right until it meets the corner edge of the wall again. Letter the lower end of the vertical line from B, F; the lower end of the short ½" vertical line, G; where the 45° line from H meets B F, I. From I draw a horizontal line to the left to meet the vertical line from A; call this point, J. From J, draw a line downward to the left at an angle of 45° until it meets a horizontal line from H. Complete the outline of this ell or porch.

Draw No. 8 the same as No. 2. Letter the lower end of the

vertical line from A, F; from B, G; and from C, H. From point A, and from the middle point of A B, the middle point of F G, and from point F, draw lines down to the left at an angle of 30°, ½" long. Connect their ends, making a rectangle, then cover the top of this ell with a roof thus: from the two outside upper corners draw 45° lines until they meet over the middle; from this meeting point, draw a line upward at an angle of 30° to the right until it meets a line running from the middle point of A B toward the upper left hand point of the main roof. At the right end of the house draw a similar ell, joined to the further half of the wall and only half the height of the house, the roof lines to be the same direction as the main roof.

Draw No. 9 the same as No. 2, then at the lower right hand corner add a tower ½" wide whose front face is flush with the front face of the front wall, and whose upper edge is ½" higher than the top edge of the wall.

From the upper left hand front corner of the tower draw a line up toward the right hand corner of the main roof a distance of 7/16"; its upper end will be the peak of a pyramidal roof to the tower, as in No. 4. Complete the roof.

If buildings, or pictures of buildings are inspected, any number of them, it will be found that their roofs will come under these heads, or at least will be but slight variations of them. If the tower in No. 9, for instance, had eight sides instead of four, there would be eight "leaves" to the roof instead of four, all meeting in a point. If the number of sides were sixteen, there would be sixteen "leaves." If the number were increased so that the sides of the tower would form a great round cylinder, the roof would still be pointed, but the sides would form a pyramid without any edges, or a "cone." Any one of the various roof examples may have their sides curved in almost any way desired, to give the vaulted roof of a cathedral, or the dome of a Moslem mosque, or a Roman Pantheon or a Columbia University library. By making the four sides of the tower roof in No. 9, each very high, we will have a church spire. If a simple gable, or double-pitched, roof has each side in two slants, the result is a "gambrel" roof.

It is hoped that the student will make a thorough study of many roofs, to make sure that he knows to which class each

belongs. In our next problem we will learn the principal facts about general roof construction.

Now, we have not learned all there is to be learned about roofs, yet; but we have made a good beginning. It is one thing to know a roof when you see it, but it is quite another thing to be able to make a sketch of it. It is one thing to know the style of any roof, the name of a particular shape; it is another thing to be able to make a scale working drawing for an architect or owner, for a definite shape and size of roof. It is one thing to say that a roof frame shall be made by a certain number of beams placed in a certain position; but it is quite another to be able to judge exactly what construction will hold for any size and shape of roof. A roof outline made by a few pencil lines on a sheet of paper has but a very faint connection with a long series of trusses and beams such as are necessary to support, for instance, the covering over the wide, open space of a railway station, or the huge dome or vault crowning some Capitol or Pantheon.

But we do not have to go to one of these vast structures to learn about the simple laws which govern the making of ordinary roofs. A roof, as we all know, is a shelter from the elements, *overhead;* such a shelter has always been needed and always will be.

The following is a simple example in miniature of roof construction. Take a board and drive a spike about 6″ long into the middle of it. 6″ in front of it on the board drive a tack; then drive two more tacks, 6″ away from the lower end of the spike placed so that all three tacks will be the same distance apart. Tie three pieces of strong black thread (or string) to the head of the spike, their lower ends being tied tightly to the tacks. Cut a piece of thin white cloth so that it will exactly cover this little frame; or pin pieces of white or colored paper to the threads. The result is a miniature tent. Four or more threads might be used instead of three. There are nine elements including the cloth which make up this little structure; name them. Note that the threads are of use only when their ends are tightly secured; the ends, then, are of very great importance.

Suppose now that the threads should be changed to wires; what new element would be added? Answer: Stiffness.

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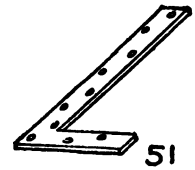

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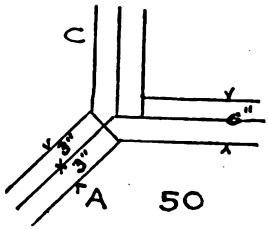

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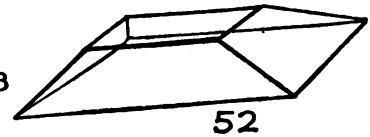

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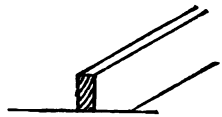

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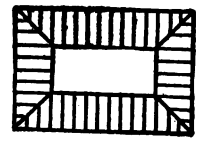

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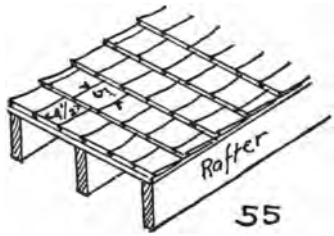

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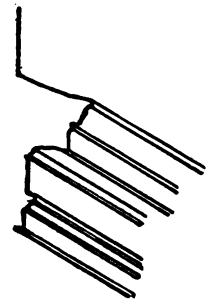

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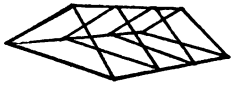

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Again, suppose the wires to be made much heavier, then the center spike will not be needed as the wires will be twisted together at the top; neither will the tacks be needed; so they may be removed. Any weight that might be placed on our little frame would be carried directly down to the board through these stiff wires, instead of by the single upright spike, as at first. The weight would be carried down slantingly instead of vertically, the ends of the wires being prevented from slipping by making holes for them in the board.

If, however, the frame is to rest on a marble top, or a piece of hard-wood, it will be necessary to join the lower ends of the three wires to prevent their spreading apart. This we might suppose to be done by cords; but they would not prevent the feet from pushing inward. The only way to make them perfectly rigid then, is by using the same strong wires as we used in the uprights. Our frame (see Fig. 43) now has six edges, or ribs; four corners, and four sides. Name three objects or structures made on this principle. The point at the top where the three wires are fastened together is strong enough to resist a great downward pull. Joining two rods or beams at the top is the principle on which the truss is formed.

If our frame were a real, full-sized tent frame, it is plain that it would easily support a canvas covering, together with any heavy wind pressure that might come upon it; also rain, hail or snow. The canvas, of course, would have no stiffness and would easily sag. Then if other rods should be run across horizontally, and secured to the main ones, they could easily be made to represent cross rods, which would prevent the sagging of the covering to a great degree; see Fig. 44. The greater the number of these, the greater would be the load coming upon the slanting corner supports. But if the cross rods were made to run downward, most of their own weight and the weight of the canvas on them would be carried by them down to the bottom rod, resting upon the pavement or wall. All roof beams are placed in this position. Fig. 46 shows a frame of larger dimensions with the uprights joined near the top by cross-pieces. Fig. 47 shows this form of frame, supporting uprights. Fig. 48 shows the same frame as Fig. 47, with the upper part removed. Fig. 49 shows the same thing with four sides. If the corner rods in Fig. 47 are made very long and steep, they

will form the frame for a spire. If the number of them is increased sufficiently they may form the frame for a conical spire. If they are bent outward to form a curve, the frame will be that of a dome or cupola.

Looking at Fig. 49, we may easily recognize which are the hip beams, or rafters; the wall plate; the deck plate; the common rafters; the jack rafters.

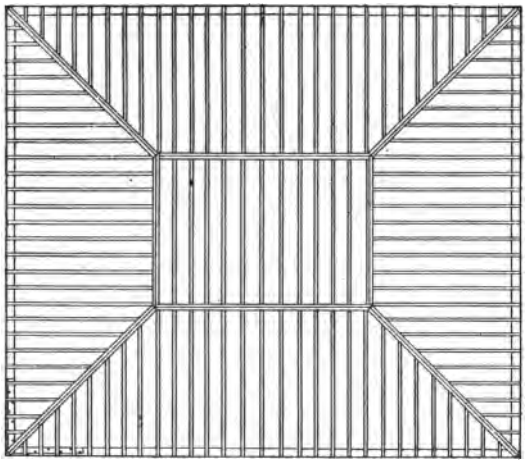
PROBLEM XIV

(See Plate 14)

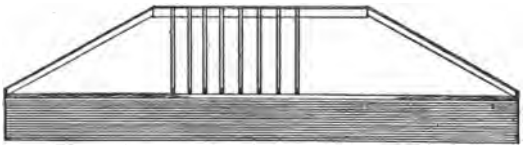
Having enquired more closely into the nature and character of roofs, as differing from the mere appearance, or pictures, or drawings, of them, we are ready to set about the actual construction of one *on paper*. The structure we are to study is one which has been erected on Long Island, and the facts about it are as follows: four brick walls 12′-0″ high enclose a well, or space, 35′-0″ wide by 40′-0″ long; the walls are 8″ thick; when the brick walls have been built to within 18″ of the top, iron rods or "anchors" 2′ long are built into them every five feet; they project 6″ above the top when the top of the wall has been finished; then the whole top of the wall is covered by a 2″ plank, 8″ wide with holes in it to fit over the rod ends; another 2″ plank is placed on top of this, making a plate 4″x 8″. Nuts are screwed to the upper ends of the rods, thus making the plate fast.

Make a plan at ¼″ scale of the foregoing structure, on a sheet 15″x 22″, placed vertically. The plan should be longest from left to right with its top line 2″ (actual) below the top border line. At each of the four corners of the top of the wall should be shown a double beam 6″ wide (8″ deep) going toward the middle of the well, at an angle of 45°, its ends resting on the corner. These beams also slant upward, but of course this is not to be seen on the plan. On their four upper ends rest the four corners of a frame each of whose sides is 6″ thick (10″ deep). The frame is 17′-0″ long (from left to right on the drawing), by 12′-0″ wide. Draw this on the plan. The corners are cut as in Fig. 50, A representing the plan of the double hip beam at each corner; B and C, two sides of the deck plate, which is also double: that is, it is made of two 3″ beams. The lower end of the hip beam rests squarely on the corner and not, as so many students are apt to make it, stopping at the inside edge of the corner.

PLATE 14.



PLAN



FRONT ELEVATION

A LONG ISLAND GARAGE ROOF
Scale ¼" = 1 Foot

The plate beams where they meet at the corners must be powerfully joined on account of the great pressure which this slanting hip beam with all the rest of the roof forcing its weight down upon it, will exert. This joint is made by means of a 6″ iron plate, 6′ long and ½″ thick, in the shape of an L, as in Fig. 51, which is bolted to the top of the plate. Draw one of these, only, showing seven bolts to each arm. The deck plates will be secured similarly at their corners; likewise, the upper ends of the hip beams (or hip rafters) are secured by ½″ iron plates. By this means, the large frame (which is very similar in shape to that of the common skylight), with its twelve different members, as shown in Fig. 52, is made to act as one piece, and is able to support any load which would be apt to come upon it.

So much for the top view, or plan. This, of course, is insufficient, because it does not show the heights. The deck frame, for instance, might be 40′-0″ above the wall plate, and the hip rafters, 50′-0″ long; or the top of the deck frame might be 7′-0″ above the top of the wall plate, as in this case it actually is; but this could never be known by looking at the plan, hence, a front view, or elevation, is necessary.

Let us then draw a front elevation making the distance from the nearest line of the plan down to the top of the wall plate 4¼″ (actual); show first the two 2″ plates; then the horizontal lines of the fifteen upper courses (each 2½″ thick) of the brick wall below the plate. Draw, next, the top line of the front deck plate, 7′-0″ above the top of the wall plate. This is the front view of the middle line (on plan) of the deck plate; its front view is obtained by projecting straight down below these points on the plan. Having obtained the two ends of this line in the front view, draw from each end a slanting line down toward the corner of the wall plate to a point 5″ directly over the corner; then draw a vertical line from this point to the corner. This slanting line as completed represents the front view of the middle line of the hip rafter. 1″ (to scale) below the hip lines draw another line; also one below the deck plate line. The space between these will represent the *bevel* of the tops of these beams. Draw the lower line of the deck plate 10″ below its top-most line. Join the two slanting hip lines at the bottom by a short horizontal line, as in Fig. 53.

Although the side of the hip rafter is 8″ wide, the front view of it will not be 8″ wide. This you can prove by such an experiment as placing your T-square in a slanting position directly in front of you, and then gradually turning it until it points away from you in the direction you are looking. As it reaches this position, the side gradually disappears, until finally only the top is seen. The method for finding the exact width of our beam we cannot go into here. It may be shown 6″ wide. For those who may be ambitious to find the exact position of this line we would suggest that if but one point in the line can be found then a line drawn through this point parallel to the upper line will be the one desired. Continue the lower deck beam line until it meets this lower line.

The entire roof frame is now completely shown. We know the sizes of the two horizontal frames, that is, the plate frame and the deck frame, and the hip rafters, besides knowing the heights of one frame above the other. Instead of one large flat space to be covered with roofing, we have now one narrow flat space and four slanting spaces, or bays. These should be spanned by lighter beams, just as the spaces in the floor frame in Plate 7 and those in the wall frame in Plate 10 were spanned. Span the two longest bays by 2″ beams (8″ deep) so as to divide the whole length into 30 equal spaces. The deck space should be crossed by 2″ beams, also running between their inside lines, and on line with the other two sets of beams. The two remaining end bays should be spanned by 2″ beams (8″ wide) also, so as to make twenty-seven equal spaces. The lower ends of the slanting beams will extend to the extreme outer edge of the plate, their upper ends stopping at the near sides of the hip or deck beams, as in Fig. 54.

A ROOF STUDY

To this point, we have learned first, how to make a simple drawing of a simple roof outline, and secondly, how to represent the construction of a roof frame, or skeleton, on paper. Now, what is a roof? We might answer that it is the third of the three most important elements in buildings. But what is a *building,* and what are these *elements* that we speak of, this floor, this wall and this roof? It would be easiest to answer this by thinking of a small one-room frame house. The *house* is a cubical space enclosed by six sides; so is a box. A house, then, is a big box. Well, what are the *sides* of a box? Boards, generally; though they may be of almost any stiff material. If the material is card board or heavy paper, it is easy to think of each side as a *sheet.* It is not so easy to think of the sides of even a small building as sheets; yet that is what they are. A sheet of paper is very long and wide, but exceedingly thin. A wall is very thin compared with its length and breadth; so is a floor. The average thickness for these in all the buildings of the world is probably one foot, whereas the average expanse of floors and walls is not less than several hundred feet. This is quite as true of roofs, a roof being a sheet placed on a slant. Four vertical sheets joined together at the corners; their bottom edges joined by another sheet; their upper edges joined by another (flat roof)—these constitute a building or house. A number of these buildings placed one on top of the other form a many storied building. Each of these "stories" may be divided again by any number of smaller vertical sheets. Bookcases, cupboards, etc., are diminutive examples of these "stories."

Now generally speaking all sheets have two faces and four edges. A floor sheet, for instance, has its upper face, upon which such a tremendous part of the life of humanity takes place; and its under face, which does no work and is merely a finish surface. A wall sheet has its outer face, which bears the

rigors of all weathers, cold and heat; and its inner face, which is finished off with plaster and kalsomine, or wall paper. It is also to this inner face that the edges of the floor are secured. The roof sheet has its outer or upper face, which receives the force of storms, loads of snow, etc.; and its inner or under face, which may or may not be finished with plaster or sheathing. Each of these three building "sheets" has, likewise, its four edges. The four edges of the floor are where it joins the wall sheets. The four edges of the wall sheet are first, the top, which either receives the lower edge of the roof, or is continued above the roof edge and is then finished so as to turn off the rain water; second, the bottom edge, where all the load of the wall above and the floors which it supports, concentrates; third and fourth, the two ends where the ends of the two other walls are joined to it. The four edges of the roof, that is, of the typical example, the gable roof of a frame house, are first, the lower, where the roof meets the wall, and perhaps extends beyond it to protect the walls from the rain water; second, the top edge where the roof sheet joins the upper edge of the opposite side of the roof; third and fourth, where the slanting edges at the ends meet the upper edges of the walls.

Let us see what we can learn about these six sides of a roof; that is, any roof. Take the top face first. The top face is a covering, generally of boards laid just like floor boards, or wall boards. This is the first layer which is nailed to the roof frame. The boards are sometimes narrow strips with 2″ spaces between them. The next layer may be made up of sheets of roofing paper laid in rows. The next is generally a layer made up of small square sheets of wood in horizontal rows about 4½″ to 6″ wide; the sheets (shingles) are about 6″ by 16″ in size. Sheets of slate are also used; as are tin, tile sheets, or blocks, copper and other metal sheets. These are always made to lap or join at the edges so as to be water tight, see Fig. 55.

The top surface of a roof, then, is a net-work of seams or cracks. These are covered or closed, as in the case of brick or wooden walls, in such a way that no wind or rain may get in.

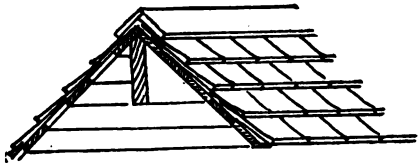
In the case of barns, or unfinished attics, there may be no under surface. When finished, 1″x 2″ boards ("furring") may be nailed cross-wise of the beams 12″ to 16″ apart (on centers), then thin strips ¼″x 1½″ nailed cross-wise of these again with

½" spaces between them. These spaces between the laths are left so that the plaster may be forced through them and thus be made to cling to them. The furring strips are often omitted and the laths nailed directly to the bottom of the beams. This is the same for the under side of floors, that is, ceilings. Fig. 56 represents a frame, which sometimes forms the under side of a roof. It shows four triangular trusses, their feet and their peaks and their sides joined by horizontal beams. It may be of wood or of steel. Upon this frame are placed the slanting rafters, across which the roof boards are laid.

The third side of the roof which we will consider, is the lower edge where it joins with the top of the wall. The roof edge may just cover the top of the wall; or it may extend beyond it one or more feet, or it may stop at the inner face of the wall just as a floor does. In any case, the rain water rushing down the face of the roof like a waterfall must be taken care of here. In the first case, the shingles may be made to project beyond the face of the wall as in sheds; or a board may be placed on edge along the top of the eaves, thus making a dam; one or more holes made in the bottom of this will let the water out into pipes going down to the ground. The whole must be tinned and the tin run up quite a distance (20") under the shingles so as to make leaking impossible. In the next case a metal trough may be secured just below the lowest edge and the water thus caught in this; or this trough may be of wood lined with sheet metal. The pipes which carry the water from this trough or gutter down the sides of the walls are "leaders" or "conductors." A groove is sometimes made *in* the roof near the lower edge.

The meeting of the lower edge of the roof with the top of the wall is very often made a very prominent architectural feature, common form of this, (cornice), being that shown in Fig. 57. The finished cornice as seen from the ground or the street shows only its outer surface. Very often it is impossible to see whether it is solid or hollow; whether it is stone, or sheet metal painted; or whether it is hollow terra-cotta blocks, or boards moulded and joined together and the whole painted.

The fourth side of the roof in importance is the upper edge; this is joined to the upper edge of the other "leaf" of the roof; that is, the opposite side. Here the roof boarding of one



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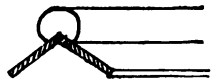

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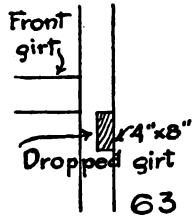

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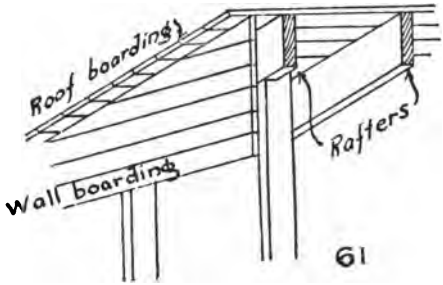

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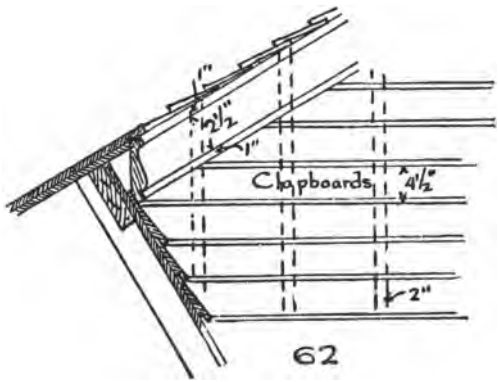

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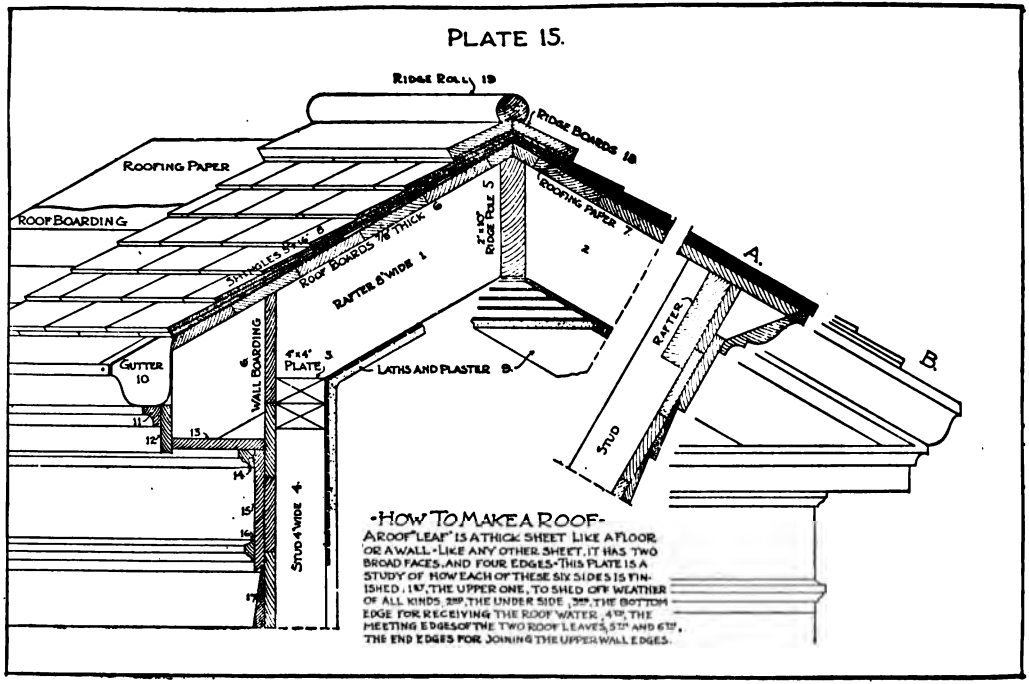
side laps over the boarding of the other, as in Fig. 58, leaving a crack at A. B shows a thickness of water-proof paper which is tacked down on top of the boarding to make it water-tight. This, of course, covers up the crack A. The shingles of the two sides meet at the peak, and they in turn are covered by 1" boards 5" wide nailed to each side of the peak, as in Fig. 59. Note in the figure how similar these "ridge-boards" are to the corner boards on the walls. This edge may be highly ornamented and made a very prominent architectural feature, as it has a right to be, being the highest portion of the building. A common method of finishing off this part of the building is by nailing a wooden roll to it, as in Fig. 60. Or this may be of sheet metal, and it may be any one of a great variety of shapes. The hips of a roof may be finished in the same way, or they may be left with an extra row of shingles on each side, overlapping.

The last two sides of a roof (fifth and sixth), the gable edges, are alike. These edges cover the top of the slanting gable wall, and also extend a little beyond it, just as the top of a table or a desk does, as shown in Fig. 61. Why are the tops of the wall studs in Fig. 61 notched out and an end rafter fitted into them? Answer: Because the ends of the roof boards must be supported. Fig. 62 is a front view with isometric lines of the upper edge of a gable wall, showing where it meets the roof edge.

PLATE 15.


RIDGE ROLL 19
RIDGE BOARDS 18
ROOFING PAPER
ROOF BOARDING
SHINGLES 5" WIDE 6
ROOF BOARDS ⅞" THICK 6
2"x8" RIDGE POLE 5
ROOFING PAPER 7
RAFTER 6" WIDE 1
2
A.
RAFTER
B.
STUD
GUTTER 10
6" WALL BOARDING
4"x4" PLATE 3
LATHS AND PLASTER 8
11
12
13
14
15
16
17
STUD 4" WIDE 4
-HOW TO MAKE A ROOF-
A ROOF "LEAF" IS A THICK SHEET LIKE A FLOOR OR A WALL - LIKE ANY OTHER SHEET, IT HAS TWO BROAD FACES, AND FOUR EDGES - THIS PLATE IS A STUDY OF HOW EACH OF THESE SIX SIDES IS FINISHED: 1ST, THE UPPER ONE, TO SHED OFF WEATHER OF ALL KINDS. 2ND, THE UNDER SIDE. 3RD, THE BOTTOM EDGE FOR RECEIVING THE ROOF WATER. 4TH, THE MEETING EDGES OF THE TWO ROOF LEAVES, 5TH AND 6TH, THE END EDGES FOR JOINING THE UPPER WALL EDGES.

PROBLEM XV

(See Plate 15)

Tack a sheet of drawing paper 15"x 22" horizontally on the board. Draw a border line around its four edges ½" from them. ½" inside of this draw a second border. As usual, all the tacking is to be done in the outside rim, the ½" margin being left for the proper finish of the sheet. We are now ready to make our final roof study. This we will do by enlarging Plate 15, drawing it to 3" scale. This enlarging can only be done in one way; that is, logically, or just as carpenters would *build* it. Shingles cannot be put on before the roof boarding; nor can the boarding be placed before the rafters are; the rafters, in turn must have the wall and the wall plate to support them at their lower ends.

Let us first locate the left hand rafter, also a portion of the right hand one, stopping at the section A. The two top lines of the rafters meet in a point, (which is also the top point of the ridge pole), 10½" (actual) to the right of the left border line and 3" (actual) below the top border line. The angle of these lines is 30° with the horizontal. The left rafter line stops 3½" (actual) away from the left hand border. Now at 3" scale draw the bottom rafter line. Draw the same for the right hand rafter. The top of the left hand plate is just 2'-0" (to scale) above the bottom border line. Its upper right corner is in the lower rafter line. Draw the upright stud below this next. The upper ends of the two rafters are nailed securely to the sides of a ridge pole, a beam which does practically the same work that the floor girder does in Plate 7. Which part of this floor frame does the wall plate resemble? The rafters? The rafter on each side, of course, represents the entire row of rafters, as the stud represents a row of studs.

Our strong frame is now completed; it is, like the frame of the human body, the part which is hidden; and our object is to enclose it and finish it off. Do not lose sight of the fact that

a roof, just like a floor or wall, is a large sheet, with six sides, two of them being faces and the other four, edges. The top one should be finished first.

Draw the ends of the roof boards as shown, also the wall boards at the left side. On top of this, show the edge of the roofing paper 1/16″ thick. Next, draw the edges of the shingles beginning at the bottom with a double row. These are ⅜″ thick at the butt and only 1/16″ at the upper end; they are 16″ long. 4½″ from the butts of the first row show the butt of the next row of shingles. Draw as shown. Show edges of four more rows. From the butt edges, draw horizontal lines to the left as shown. Beginning at the bottom row, mark off the joints, making the width of the shingles 5″, each row breaking joint with the row below it. The advantage of this method is very great as it produces an effect which is very vivid and realistic. The final covering of the rough wall boarding, that is, Nos. 15, 16, 17, (see Plate 15), may be made now. To the left of the shingles on the left side should be shown the rough boarding, and at the top of this, the roofing paper. This completes the upper or outer face.

The under face of the wall should now be lathed (laths ¼″x 1½″, and ½″ apart) as shown, and the same plastered, making the total thickness for lath and plaster ⅞″. Finish completely the above, before going any further.

The next of the six sides in importance is the lower edge, or the cornice edge. Note that the end of the rafter is carried several inches beyond the outside face of the wall, the gutter thus being placed at the proper distance from the wall, so as to prevent its leaking into the building. Draw very carefully No. 10, the sheet metal gutter which runs under the shingles a distance of 5″. Draw No. 12, the fascia; No. 11, the moulding; No. 13, the planceer; No. 15, the frieze; No. 14, the bed mould; No. 16, the architrave mould, and No. 17, the finish siding, which is practically the same as clapboards. From their lower left hand points, draw horizontal lines as far as the border line.

The fourth of the six sides which we will take up, is the upper edge, or ridge. This is very simply treated by nailing a board to each side of the slope, as shown in No. 18. A ridge roll may be added for finish. Draw carefully as shown.

Let us look at the right hand rafter, No. 2, for a moment. If we can think of this as the first rafter in the row, the one which fits into the tops of the front row of wall studs, then this will be at the fifth side, that is, the front edge of our roof. The sixth side being just the same as the fifth, this explanation will serve for both. The dotted line passing across the end of rafter No. 2 represents a line through which a saw has been passed. The sawed surface thus made would show us just how the various parts here are joined together. Fig. A, or section A, shows this sawed surface, turned or revolved, so that we can make a drawing of it. Draw first the rafter end, then the stud, then the rough boarding, (roof and wall), then the shingles, the frieze, siding, and finally the slanting cornice mould. Fig. B shows the outside view of the fifth and sixth edges at their lower end, or the corner of the building. Draw this in very carefully and just as it is shown.

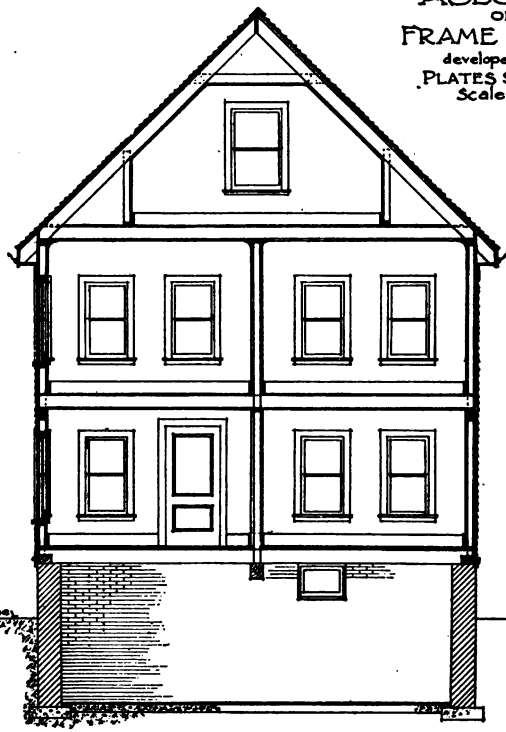
Print all the lettering carefully, making the ordinary letters $\frac{1}{8}$" high. The entire drawing should be done in ink and perfectly cleaned with a soft rubber.

PLATE 16.

A SECTION OF FRAME HOUSE

developed from PLATES 9 AND 10

Scale ¼" - 1 Ft



PROBLEM XVI

(See Plate 16)

We have now accomplished what we started out to do; we have actually constructed on paper a floor, a wall and a roof, We have placed the beams side by side, thin and tiny beams, to be sure; also stood them on end to make a row for a wall; then we have arranged them so that they formed a strong rigid frame, or bridge, resting on the top of four brick walls, to form a roof. We will now find out just how to make a single drawing in which the floors, walls and roof of an entire building may be shown joined together.

The floors and walls we shall use are those which we made in Plates 7, 8, 9 and 10. The roof will be slightly different, but even simpler, than the one which we have just finished. First tack a 11″x 15″ sheet vertically on the board; draw the border lines; draw a light vertical center line; 3″ above the bottom border line draw a light horizontal line across the sheet. Mark this, "Ground Line." At ¼″ scale, draw, 2′-11″ above this line, the top edge of the brick foundation wall (front view) in Plate 8. Complete this front view of it, but instead of hiding the part of it below the ground, show the entire height (8′-0″ high, 24′-2″ long), just as though the earth were taken completely away from in front of it. Show also the 8″ footing wall upon which this rests, projecting 6″ at each end. The ground line may be stopped at each end of the wall. Next show the sill resting on top of the foundation wall as in Plate 8; then show the wall-plate in the same position as in Plate 10, its ends resting on the 8″ corner posts. Show also the 8″ girt as in the same plate. Our drawing now represents the outline of a single wall from the lowest part to the highest; from the footing where it rests on the ground at the bottom of the excavation, to the wall-plate where the roof begins. The studs should not be shown in this drawing.

Let us now mark off on the brick wall, at each end of it, a

space 16″ wide where the two side walls will begin; these, of course, are to come toward the observer. Mark off, also, on each end of the footing a space 2′-4″ wide where the two footings for these side walls will begin. At each end of the sill, mark off spaces 8″ wide where the sills will begin. At each end of the plate, do the same for the end plates. The space for the two end girts is as shown in Fig. 63, these being lower than the front girt; it is called the "dropped" girt. Now to explain; and, as we hope, to make it very clear. The lines which we have shown may be supposed to represent chalk lines or pencil lines right at the ends of the walls and beams themselves; they are the spaces where other beams and walls are to be joined to those which we already have. Now suppose that the walls and beams have become joined—how shall we put them on our drawing? Why, in the simplest way imaginable: by drawing 45° lines up to the right, and about 1/16″ (actual) apart, across the end spaces of the foundation walls; thus showing that our spaces have become the ends of walls. The footing walls, being made of broken stone, sand and cement, should have their ends shown as in Fig. 64, the larger spots representing the stone and the smaller dots the sand. To show that the end beams have been put in place, simply draw a few wavy lines to represent the rings which are found at the end of beams, as shown in Fig. 65. We have now shown the ends of the two foundation walls joined to the end of the first foundation wall; also the footings underneath them; also the three main beams for each of the end wall frames. The ground underneath the surface is shown as in Fig. 66. If, then, we make a few of these marks under the ground line, and outside the foundation wall, as well as along under the footing, it will be given, instantly, the appearance of the ground. The student, at this point, should be able to answer this question: What did the vertical line drawn at the end of the main foundation wall, 16″ from the end, represent? The answer, of course, is that this little line on paper 2″ long represented an eight foot line (chalk or crayon) on the face of the brick wall. Another question; why is it necessary to cover this end space with 45° lines, that is, "cross hatch" it? Answer: It is only in this way that we can show that a wall, coming in the direction of the observer, has been joined to the end of the main wall. Is it possible to tell how long this wall

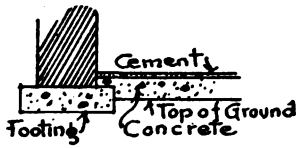
is by looking at this view? No; it looks just the same, whether it is a foot long, or whether a hundred feet long. Ask yourself these same questions about the little beam ends; also the footings.

On top of the left end sill will rest a row of 2″x 4″ studs, the 4″ side showing toward the front. On top of the end girt there will be the same. Their outside faces will be in the same line as the outside face of the corner post. Draw their inner edge. Draw the same for the right end wall. Do not show the studs along the main wall. Our drawing now shows three walls; four walls, of course, are needed to enclose a building, but it is evident that we cannot show the fourth or front wall without hiding the other three.

The ground inside of the foundation walls is supposed to be removed in order to make a cellar. The top of this ground after the excavating will be shown by a horizontal line running between the footings and just 3″ below the top of them. In some cases the ground is left in this way without a covering of any kind, but it is much better if it is covered with a 5″ thickness of concrete and this, in turn, covered with a finish layer of cement. Show as in Fig 67.

It will be noticed that we have shown no floor beams yet; there is no place to walk upon except the cellar floor which we have just completed—or possibly the tops of the walls. Now by stretching beams across from left to right with each end resting on an end wall, we will lay the frame for a floor. Fig. 68 shows how the end of the floor beam is notched to fit over the sill. Draw one of these floor beams resting on top of the end foundation walls. This, of course, will represent the whole row, or as many as are necessary to bridge over the whole space for the first floor. Directly under the middle of this beam draw a small vertical rectangle 8″x 10″, with its top side touching the under side of the floor beam. This will represent a hole in the face of the main foundation wall into which will be fitted the end of a heavy beam, 8″x 10″ in section, which will come directly toward the observer. Indicate the beam. What is this beam needed here for? Answer: To support the row of beams at their middle points.

The ends of the second floor beams will rest on the end dropped girts; and as they are exactly the same height as the



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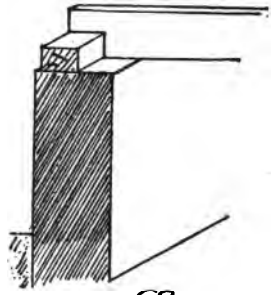

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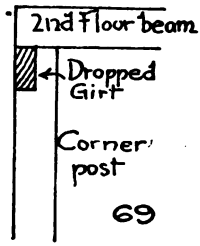

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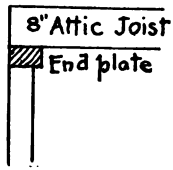

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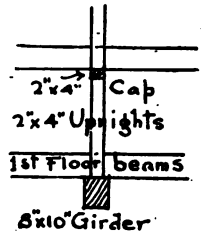

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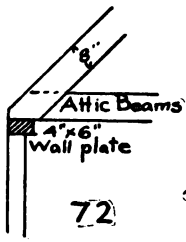

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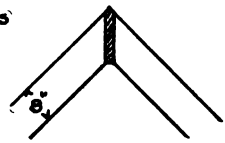

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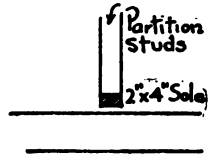

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main girt, the lines of this girt will also be the lines of the floor beams, as in Fig. 69.

The ends of the attic floor beams, also, will run from left to right, their ends resting on top of the end plates, as in Fig. 70.

We must now attend to the supporting of the second and third floors. The girder under the first floor, which we see only in the end view, will be supported about every eight feet of its space by uprights, whether they are iron pipes, wooden posts or columns, or stone or brick piers. But as our view of it is supposed to be taken at but a slight distance from the main wall, say one foot, no piers need be shown.

If a 2″x 4″ beam is laid flat, with its end toward the observer and so that the second floor beams will rest on top of it at the middle, the beam, itself, ("cap") resting along the top of a row of studs as in the outside walls, and themselves resting directly along the top of the 8″x 10″ girder, the drawing will appear as in Fig. 71. The row of studs resting on the second floor and running up to support the attic floor will rest directly on top of this cap, and on top of them will be still another cap for the attic floor beams. If you will look carefully over your drawing now you will note these important facts: first, that the view of the main sill is hidden by the first floor beams in front of it; second, that the girt is hidden in the same way by the second floor beams.

Returning to our cellar for a moment, notice that our foundation wall is just a blank space; it might be plaster or cement for all we can tell from looking at it. But it is a brick wall; and in order to make it look like a brick wall, we must draw horizontal lines (not all the way across; about one quarter) 2½″ apart. These heights are measured most easily by laying off 30″ (2′-6″) and dividing this into thirds, next divide each of these thirds into halves, by the eye, and each of these halves again into halves, these smallest divisions then being the heights of the courses. Draw forty or fifty vertical joints, making the brick lengths 9″.

The framing or skeleton for our main structure is now complete from the ground up to the plate. It needs but the finishing inside and out, from the outside paint and clapboards, to the inside wall-paper and plaster. The top, however, or roof is yet to be constructed. What is the space enclosed by the roof

called? A beam, with its foot resting on the left hand plate and itself slanting up to the right at an angle of 45°, will form part of the frame to which the roof boards and shingles will be nailed. A beam, resting on the right plate in the same way and meeting the first one over the middle of the building will form part of the right side of the roof. Draw these beams resting on the plate as in Fig. 72. Their upper ends instead of being nailed together are nailed to a board, which runs in the same direction as the girder in the cellar, showing us only the end view, as in Fig. 73.

Now, the space between the roofs is, of course, much less desirable for living in than the rest of the house on account of its awkward shape. The middle part is the best, because there is plenty of height there; whereas, at the edges, there is no height at all. A room, or rooms, can be made in the middle part by building a row of studs on each side of the middle. Draw, then, 7′-0″ each side of the center line, a 4″ stud (which is the same as a row of studs), show under these the end of a 2″x 4″ beam, laid on its *flat* side and raised 1″ above the top of the joists, as in Fig. 74. The 1″ space is left for the layer of flooring. The tops may be nailed to the rafters. 8′-0″ above the floor beams, draw a 6″ ceiling beam (this stands for a row of beams). Nail its ends to the sides of the rafters.

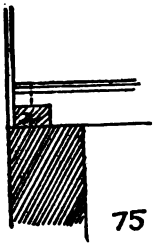
As our building stands, it is open to the daylight from the top of the foundation walls to the peak, whereas by covering the outside of our skeleton with a layer of 1″ boards, it will be entirely enclosed. To perform this on our drawing, draw a vertical line up the outside of our walls 1″ from them and then 1″ outside our rafters, until they meet at the peak. Show a layer on top of each of our floor frames, extending all the way to the inside of our wall boarding, in each case. The attic floor boarding will be stopped by the roof boarding. This boarding is shown in the same way that the wall boarding is; that is, by a single line 1″ above the top of the floor beam. Figure 75 shows the joining of the left hand end of the first floor with the sill on top of the foundation. An extra thickness of flooring is shown. Note that the inside stud line is dotted, because it is hidden. The boarding on the main wall, too, has been placed, although we do not show it.

Just as we have shown a layer of boarding on the outside of

our walls and roofs, and on the tops of our floors, so we shall now show a 1″ layer of lath and plaster (⅞″ to be accurate) on the inside face of our walls, the under side of our roofs (in the middle, or finished part) and the under side of the floors, thus finishing and enclosing the interior walls and ceilings. As the main, or rear, wall is to be plastered, also, it is evident that the corner posts will be hidden; therefore the inner line will be erased in each case. Erase also the lower line of the plate. Draw the plaster lines down each side of the first and second story middle partition studs, as of course they must be covered with plaster, too. Where the two end plates project beyond the second story plaster, the plaster may be rounded into the form of a cove, as in Fig. 76. The same cove should be made at the middle partition.

As our structure now stands, it is entirely enclosed and separated into four horizontal spaces, or stories, by floors; these again being divided by walls into smaller spaces, or rooms. Well, to make a long story short, the building is of no use to us as it stands, as no human being could live in it; there must be air and sunlight and, of course, it must be possible for people to get in and out. For the former, we must have wall openings, or windows; for the latter, doors. Again, if we are to get up or down from one floor to another, there must be openings in the floors, such as stair wells; these will be considered later under "stairs." The whole subject of wall and floor openings is of the greatest importance and will form a chapter and plate by itself. Doors and windows are universally oblong in shape, and the good appearance of a wall, as well as of the openings, depends to a great extent upon their being made of the proper size, and in the proper place.

After much study the author has decided that the most desirable size for the window-openings, in the first and second story walls, is 2′-4″ wide by 4′-3″ high. The most desirable location for these openings is, measuring from the inside of the boarding on the right end wall, to the first openings in the first and second stories, 2′-6″; the width of the openings, 2′-4″; from the left side of these to the next openings, 2′-6″; width of the second openings, 2′-4″. The bottom line of the first floor openings is 1′-9″ above the floor; of the second floor openings, 2′-0″. Measuring these same distances from the right end wall we can lo-



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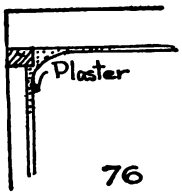

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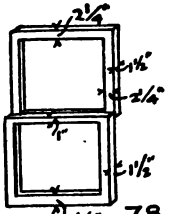

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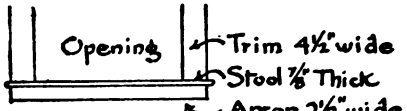

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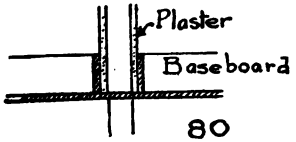

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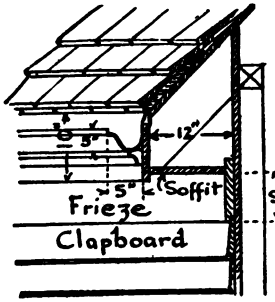

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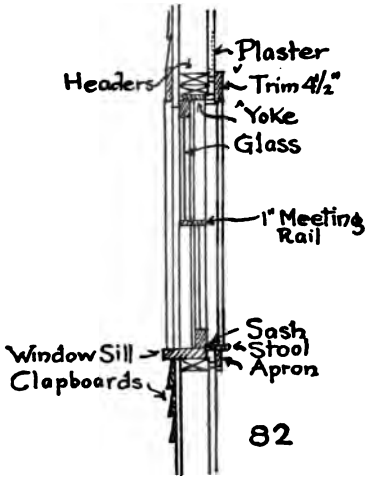

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cate the two openings in the main wall for the upper story, and in the lower story, the first opening. The door in the first story is 2′-2″ to the right of the left hand window; it is 3′-0″ wide. Around the two sides and the top of these seven window openings should be drawn a border, or "trim," 4½″ wide. At the bottom is a little shelf, or "stool," ⅞″ thick, upon which the trim rests, as in Fig. 77. The 4½″ trim is placed also around the door opening.

In the attic main wall, there is one opening in the middle; its size is 2′-9″ wide by 4′-6″ high, and its bottom line is 2′-0″ above the floor. The trim, stool and apron are the same size as for the other openings.

The openings are now provided for, their size and position, etc.; but they are still open to the weather and it is necessary to enclose them with glass. Two sheets of glass are enough for each window, each about half the size of the openings. In order to make these sheets so that they can be raised up and down, they must each be fitted into a wooden frame, or "sash." Figure 78 shows the size of the pieces of the frame. They are all the same thickness, looked at edgewise, 1½″. From the front, in the position in which we see them in our drawing, they are all 2½″ wide, except the bottom rail, which is 3½″ wide, and the middle rail, which is 1″ wide. The middle rail is just half way between the upper and lower rails. These sizes are the same for all the windows.

The best method of drawing in these sash after the frames are in, is to draw a line around the two sides and the top, 2½″ from the sides of the opening, as in Fig. 79; then one across the bottom 3½″ from it. Next, find the centre point of this inner rectangle, and then draw the middle rail 1″ thick. Draw these for all openings.

The door opening yet remains to be enclosed by a door. Make its total height 6′-8″. The window openings were filled with the two frames with glass in them; but the doorway will have only one frame. The two side pieces to this frame (or door) are 5″ wide; so is the top. The fourth or bottom side we will make 10″ wide; 1′-6″ above the top of this draw another horizontal cross-piece, 6″ wide. The space between is filled with a panel of wood. The space between the middle rail and the top rail will be filled with a sheet of plate glass. Around the edges of the

glass as well as the panel should be shown a strip of wood moulded and 1″ wide. We have not yet shown any openings for light into the cellar. These are generally square-shaped, running from the top of the foundation wall down about two feet. The 6″x 8″ sill for the wall frame acts as the head for the window. Let us show such an opening directly under the third opening from the left; the top of the opening will be the under side of the first floor joists; the width will be 2′-8″, and the height 2′-0″. A frame made of pieces 1¾″ thick should be shown around the four edges, and inside of them the four sides of the window sash, making them the same size as in the other windows. Draw these in very carefully. Draw also a few brick courses on each side of the opening so as to make the latter stand out very clearly.

Now our plaster runs all the way from the ceilings down to the floors without any protection from the feet of chairs and other furniture. It is always necessary to nail a wide board to the wall where it meets the floor ("baseboard"). Show then in the attic, second and first stories, a board 1″ x 8″ running along the wall, and when it reaches the end walls, coming end on toward the observer, as in Fig. 80.

The outside of our frame is securely boarded in; but it yet needs a layer of finish boarding as well as a layer of weather paper to make it perfectly tight. The roof boarding must be covered with rows of shingles and, in places, sheets of tin to finish it. At the point, or edge, where the roof boarding joins the wall boarding, unless the roof is carried beyond the edge of the wall, there will be a steady sheet of water flowing over the edge and down the face of the wall, when it rains hard. Therefore the roof beams must be continued down past this point until their vertical edge is 1′-0″ beyond the wall boarding, measured at right angles to the boarding; the boarding is continued directly down to the edges. Then just below this, the gutter is hung as in Plate 15, and various boards are nailed on to make the proper finish to the rafter ends, as in Fig. 81. Draw from this figure onto your drawing with great care, getting the sizes for shingles and clapboards from Plate 15. Draw also ridge boards. Omit the ridge roll.

Note that where the sill end of the left end wall meets the top of the foundation wall, there is a crack, or joint. This

joint may be covered by a 1″ board, 6″ wide, whose lower edge is 2″ below the crack. The upper edge of this should be slanted off so that a narrow board slanting down at an angle of 45°, and extending beyond the first board, may be nailed to it. This forms a small roof for shedding off the water which has flowed down the surface of the wall. It is called the "water table." Starting from the frieze at the top, the clapboards should continue until they reach the water table. Draw all the ends of the clapboards on both walls, and all the ends of shingles on both roofs, getting the sizes from Plate 15.

There remains yet a small exercise before our plate is finished. Referring to the left end wall, draw a short horizontal line across the width of it, from the inside of the wall boarding to the plaster line, at the height of the under side of the trim across the tops of the window openings, in the first and second stories. ⅛″ above each of them, draw another horizontal line of the same length. Each of the very small horizontal rectangles made by these pairs of lines marks the space where the end of the horizontal board, ("head" or "yoke"), will be placed. Cross-hatch the space and it will show that the boards are in place.

One-half inch above each of these boards show the end of a 2″x 4″ beam ("header") resting directly against the stud. Next, find a point on the plaster line, at the height of the under line of the window stools in the main wall, and draw from this point a line slanting downward to the left until it reaches a point 2″ beyond the outside of the wall boarding and 1″ lower than where it started. 1¾″ below this line, draw another slanting line parallel to the first, and connect the ends. This will represent the end of a board ("window sill"). Below this show the end of a 2″x 4″ beam whose upper left hand corner touches the under side of the window sill. The ends of these four pieces having been located for each story, the remaining pieces may be placed as shown in Fig. 82. Draw these pieces in as carefully as possible, locating first, of course, the headers, at the top, and the bottom cross-stud, the yoke at the head, and the sill at the bottom. The whole window drawing will be shown later at a large scale. The right end wall should be left plain with only the plaster, wall boarding and clapboards shown.

The student who has succeeded in carrying out these direc-

tions for the making of Plate 16, and who feels sure that he could make the drawing over again step by step *from memory*, has advanced a long distance toward the mastery of architectural drawing. The plate just completed might be called an interior elevation of the main wall together with all the edges of two other main walls, all the floors and the roof; it is one of the most difficult of the architect's drawings, and is known as the "Section." It is of such importance that the author advises the student to make a second drawing, entirely from memory.

As in all the other plates there must be a title for this plate. The most satisfactory place for this title is in the upper right hand corner, spaced as in Fig. 83.

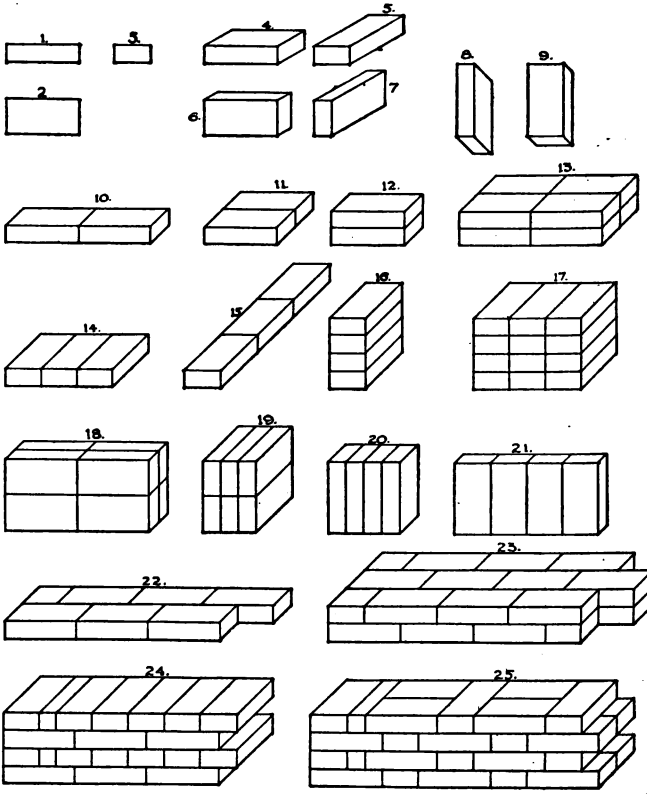
PROBLEM XVII

(See Plate 17)

We have discussed in a broad way the main combinations of wood members, such as beams, boards, shingles, clapboards, etc., to make wooden buildings, and in general, frame structures and framing. We should now be ready to learn all that is possible about the structures which are made by blocks of stone, bricks or terra cotta. The shapes and sizes of bricks, as well as the way in which they are fitted together to make strong walls, are represented in Plate 17. Place a sheet 11″x 15″ in a vertical position upon the board. Draw the border lines. At the upper left hand corner of the sheet, draw the front view of a brick laid flat with its long edge to the front; No. 1 on the plate. It will be ¾″ from the left border and 1½″ from the upper border; the size of the brick is 2″x 4″x 8″ at the scale of 1½″=1 ft. ½″ (actual distance) directly below this, draw the top view, No. 2. ½″ (actual) to the right of the front view draw the side, or end, view, No. 3. ⅛″ under each view, letter carefully the view name in letters ⅛″ high. These are the three different sized faces of the brick, the other three being the same as these. They show the exact size and shape of the brick; the method of thus drawing an object, as we have already seen, is called "Projection."

For the second group to the right, draw the first group again, ¾″ (actual distance), adding the fourth view, No. 7, to them. Draw slanting lines upward at an angle of 30° to the right as shown. Their length, of course, is less than the actual length, and is determined, as indicated in Fig. 84. The third group of two drawings explain themselves. The space between No. 7 and No. 8 is 1″, (actual). The slanting lines are drawn *down* to the right at an angle of 45°, their length being determined as in Fig. 85. The last six drawings, that is, Nos. 4, 5, 6, 7, 8, 9, are practically the only positions in which bricks are used in building. Nos. 4 and 5 are the commonest; Nos. 6 and 7 are

PLATE 17.



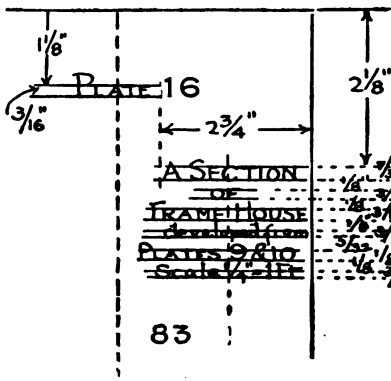
THE COMMON BRICK AND ITS COMBINATIONS.

much less common, No. 6 being the position in which stone facing on city buildings is laid; also tiling in bath room walls, etc. No. 8 and No. 9 positions are rarely used, except to produce ornamental effects. See if you can draw these six figures from memory. Draw them two or three times.

It is necessary to join bricks together in order to make any part of a building. The second row of our plate beginning with No. 10 shows how bricks in the position of No. 4 may be united. The distance of the bottom line of this row from the bottom line of row No. 1 is 1½" (actual); the first group, No. 10, shows the two bricks joined from left to right; No. 11, from front to rear; No. 12, from below upward; No. 13 is a combination of all three. No. 10 shows how bricks are placed so as to give *length* to a wall ("stretchers"). No. 11, to give thickness; No. 12, height; No. 13, shows really four groups of No. 12. Each little group in No. 13 is separate, with nothing but the mortar to keep them together; bricks, placed thus, have no "bond," therefore they do not form a wall. The actual spaces between these four groups (that is, between the edges of their front view) should be ¾". The slant of the lines is 45°. Draw this row carefully at 1½" scale.

The distance of the bottom line of the third row below the bottom line of row No. 2 is 2" (actual). Angle of lines 45°. Distances between front views of groups, 1", 1½", 1½". In this row the same method is used as in row 23. The brick in its second position (No. 5), which is called a "header," is here shown in groups of three and more; beginning at the left is a row of bricks joining each other from left to right in the direction of a wall's length; the next from front to rear, to make the wall's thickness; the next from below, up, to make height; the last being three groups placed edge to edge. Bricks placed in this position, with their ends toward the front are always "headers." Placed lengthwise they are—what? Notice that the last group in the third row do *not* make a wall; each little pile is separate from the other; they are not united in any way; they have no "bond."

For the fourth row, the distance between the bottom lines of the third and fourth rows is 2" (actual). Distances between the front views of Nos. 18 and 19, ¾"; 19 and 20, 1"; Nos. 20 and 21, ¾" (actual). Slant of lines 45°.



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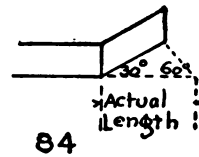

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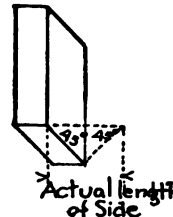

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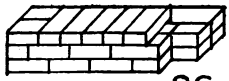

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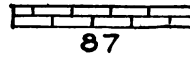

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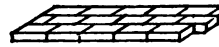

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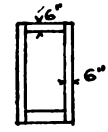

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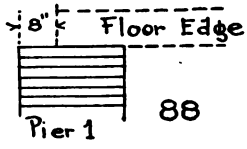

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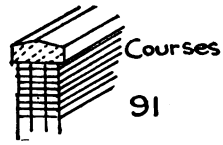

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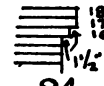

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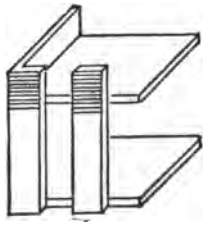

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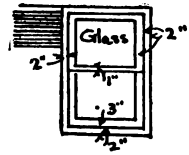

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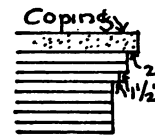


95

No. 18 represents eight bricks in the third position (No. 6) placed so as to give length, thickness and height, but not forming a wall with bond.

No. 19 represents six bricks in the fourth position (No. 7). It is practically in this position that bricks are placed to make all "relieving" arches as well as other kinds.

No. 20 shows four bricks in the position of No. 8. These occur also in arches over openings; also to give an ornamental effect to walls.

No. 21 shows four bricks in the position of No. 9. Tiles are very often placed in this position.

For the fifth row, the bottom line is 1½" (actual) below the bottom line of the fourth row.

The first group shows the bricks in the first position, (No. 4). It shows two rows of stretchers (No. 10), placed one behind the other; three in the front row and three and a half in the rear row. This is the same position in which they are shown in Nos. 11 and 13. Looking at No. 13, you will see that if you were to give one of the bricks in the front row a push toward the rear, there would be only one brick to prevent its being moved. But, by placing the bricks, in the rear row, as shown in No. 22, the brick in the front row would be resisted by two in the rear row. This is "bonding," horizontally. The great benefit of it is easy to see.

In group No. 23, look first at the two front rows, one on top of the other; then look at the two front rows in No. 13. Explain, if you can, why one is much better than the other. The second and third bricks in the bottom row of No. 23 cannot possibly separate sideways on account of the weight of a single brick on top of them; especially when the weight of other bricks comes on top of this brick again. The same is true of the next two bricks in the bottom row. In the two other rows back of this front row, the bricks are placed in the same way. This up and down bond is called "vertical" or "plumb" bond. No. 23, then, is an example of both horizontal and vertical bond. Still it does not form a perfect bond. Look closely and you will see that there are three separate little walls, two rows high. There is nothing (but the mortar) to prevent the two little outside walls from falling outward: they are not joined together. If now a row of headers (No. 14) could be placed

along the front, they would hold the two front walls together, as in Fig. 86, and the two little rear walls could be held together in the same way.

There are several other methods by which these little four inch walls are bonded together, but this is the simplest. The Building Law of New York City (1906) requires that where this method, shown in Fig. 86, is used, every sixth course shall be a "heading course."

For the sixth row, the bottom line is 2" below the bottom line of the fifth row. Draw first in No. 24, the front view of the bottom course, three stretchers. On top of the second and third, in the middle, show a brick end, or header. Draw two headers on each side of this. The narrow end at the left is called a "closer." Draw the other two courses of brick as shown, with their isometric lines. This is a very important form of construction and is called "English bond." To really *learn* this bond, two or three copies of this drawing should be made from memory. The main thing to remember about "English bond," is that the bricks in one course are laid at right angles to the course below and above it; a course of headers comes between two courses of stretchers. $\frac{1}{4}$" below No. 24 draw lines for lettering, $\frac{1}{8}$" apart. Letter "English Bond."

In No. 25 draw the bottom row first, as in No. 24. That is, beginning at the left, draw a stretcher first; then a header, etc. The top row shows how these are placed for an 8" course. The second row above the bottom row is exactly the same as the bottom, the bricks being placed so that each header comes directly over the middle of a stretcher below; and the middle of a stretcher directly over the middle of a header. A closer is used at the end, as in No. 24. Draw the front view of the four courses first; then their isometric lines at an angle of 45°. Draw the title below, as in No. 24, "Flemish Bond." This is one of the handsomest arrangements of bricks in walls. A few drawings of this from memory will serve to fix it in the mind so that it will not be forgotten.

PROBLEM XVIII

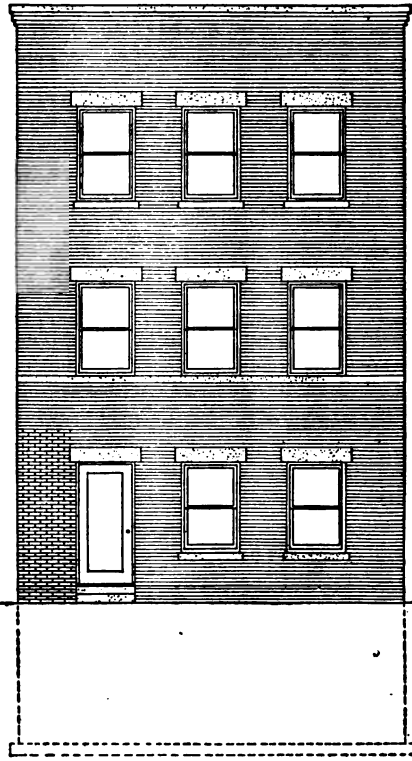
(See Plate 18)

The beginning of a brick wall is a single brick, laid in the position shown in No. 4, Plate 17.

Place sheet vertically. Draw the border lines, also a vertical center line. Draw $3\frac{1}{2}''$ above the bottom border line a horizontal line across the sheet. Mark this line at one end A, at the other, B; call it A B. At $\frac{1}{4}''$ scale draw on this line a horizontal rectangle $2\frac{1}{2}''$ high by $8''$ long, and so that the left hand end of it will be $11'\text{-}0''$ from the center line. This will represent the front view of a brick laid flat on the ground, that is, on top of a stone foundation wall, which comes just to the top of the ground. Draw to the right of this the front view of a second brick, and then three more to the right of this, making a row of five altogether. The distance which this row goes back is, of course, the width of the brick, or $4''$. Suppose a second row to be placed back of this front row; the width will be made $8''$; a third row will make the width $12''$; of course, this width or depth, cannot be seen from the front. This $12''$ will be the width of our course, although all we see is the $2\frac{1}{2}''$ height and the length of the front face. No. 22 on Plate 17 shows the isometric view of two of these rows. On top of our first row of five stretchers, draw a second row of the same length, with the bricks breaking joint, as in the front row of No. 23, making for our second row, a header at each end and four stretchers in between, as in Fig. 87.

Our wall, as thus far built, will appear just as in No. 23, only a little longer; three double rows of bricks. But our drawing on Plate 18 should not show the slanting lines of the isometric; only the front view, as in Fig. 87. Two more courses of brick, the same as these two, may be shown on top of them, making our wall now four courses, or $10''$ high. Add four more courses on top, showing also the little vertical joints; then add four more, again making a total of twelve courses, or 12 times

·PLATE 18·



ELEVATION OF
BRICK DWELLING
SCALE: ¼"=1FT.

$2\frac{1}{2}'' = 30''$ $30 \div 12'' = 2'\text{-}6''$. It is clear from this that if we lay off a height of 2'-6" above this row, or 30", and divide this carefully by our eye into three equal parts, each of these parts will be 10"; then if we divide each of these 10" spaces into two equal spaces by our eye, each will equal 5"; divide each of these again into two equal spaces and each will be $2\frac{1}{2}''$ or the height of the brick courses. Now continue our brick courses up until there are forty-eight altogether; how many feet in height does this make? What is the width of this wall, if these are five stretchers each 8" long (not allowing for mortar)? Answer: 40", or 3'-4". The shape of this wall is tall and narrow; therefore it is a pier. What is the remaining "dimension" of the pier, or its thickness? Answer 12".

Next, 3'-4" to the right of this pier draw the front view of a second one, making it, however, 2'-8" wide or four brick lengths. Its height and thickness are the same. Draw the horizontal lines of the brick courses only. Again, 3'-4" to the right of this pier draw a third pier the same size as the second. Draw the horizontal brick courses. Lastly, 3'-4" to the right of the third pier, draw a fourth pier the same size as the first. 12" above the ground line, A, B, and behind the piers is the top edge of the ground floor. The front view of this top edge is, of course, a horizontal line. Draw the same in a light dotted line. The front edge of a floor may be shown by a long, narrow horizontal rectangle in dotted lines. Now at the tops of our four piers show the front edge of a floor in this way, with its lower edge on a line with the tops of the piers; its height, or thickness is 12" and its ends rest on the side walls. The floor edge then, should run to within 8" of each end of the end piers, as in Fig. 88. Remember that the front edge of this floor comes only to the inside face of the front piers; it does not rest on them. (Note: This edge might also be that of a flat roof). This being the case, it is easy to see that our piers, 1, 2, 3 and 4, may be continued on upward. Continue each pier thirteen courses higher, by the method used before.

Fig. 89 is a view of a portion of our two floors, the side wall and the front row of piers. Now, it is easy to understand why there are four piers along the front; but why are the spaces left between them? Answer: Without the spaces no light nor air could reach the inside, and no one could live in it.

Let us suppose for a moment that our upper floor edge is in reality the edge of a flat roof. It is instantly clear that the open spaces between the tops of the piers are danger points, and that they ought to be closed up for protection to anyone walking on the roof. A brick wall may be built in this open space, if a strong piece of stone, or some other material is placed across the opening with its ends let into the sides of the piers; on top of this, the wall may be built. On the right hand edge of pier 1, remove 4″ of the ends of the fortieth, forty-first, forty-second and forty-third brick courses; directly across, remove 4″ of the ends of the same courses in pier 2. Remove the same at the other four pier edges; that is, two for each opening. Show blocks of stone stretching across these openings with their ends fitting into these 4″ spaces. Make a few dots on their surfaces to make them appear like stone. Erase the six inside vertical lines of the piers above the stone lintels, and continue the horizontal brick courses directly across the space between the piers on top of the stone beams.

If we could see the top of the top course now, we would find that it consists of a great many bricks as well as a great many cracks between them, filled with mortar, as in Fig. 90. As it would be ruinous to a building to leave the top of a wall thus exposed to rains, which would make their way into the wall and into the building, it must always be covered tightly with large slabs of some material; generally long bluestone blocks. These, in order to thoroughly shed off the rain are made wider than the wall itself, (1″ on each side) and their tops instead of being left flat are pitched like a roof, as in Fig. 91. This extra line need not be shown on our drawing.

The student should be able to answer the following questions, before going further: 1. What is the total load of the four brick piers, the stone "lintels" and the brick courses above them, resting on? Answer: The top of a stone foundation wall. (In order to indicate this foundation wall below the ground, merely continue the end vertical lines of our wall down a distance of 8′-0″, in dotted lines; then connect their ends by a horizontal line. An 8″ footing may be shown below this, just as in the case of the footing on Plate 16, projecting 6″ outside of the foundation wall). 2. What is it that actually receives the weight of the wall over the stone lintels? Answer: The

piers. The stone beams, or lintels are not of the full thickness of the wall, being only 4″ thick. Behind this lintel then there must be either another lintel, or a beam, or an arch, to support the remaining 8″ thickness of wall. The reason for this is that the lintel, as shown on our drawing, is a "show" piece, and is made so that it will *look* well; the part behind it is never seen, so it is generally made of two or more rows of common bricks in the form of an arch. This will be gone into later.

Our drawing now shows a brick wall with three openings, all of the same height from the ground or sidewalk. Let the first opening at the left be a door; the other two, windows. Divide the height of the floor edge at the bottom of the door opening into two equal heights to represent two stone steps. Next erase the vertical edges of the piers at the side of the other two openings up to the height of the fourteenth course of bricks; then continue the lines (joints) of the first twelve courses across the bottom of the openings. Next, remove 2″ at the end of the 13th and 14th courses at the sides of these two openings. Draw stones two courses high at the bottom of the openings with their ends fitting into these 2″ spaces. Make small dots on them to make them appear like stone. These are window sills. They will be taken up in detail later.

The front, or street wall of our building with its three openings is complete now. Let us enclose the openings now with glass. As we have seen before, our sheets of glass for the windows are framed, the pieces for the frame being 2¼″ wide; for our door we will use a large plate glass fitted into a frame whose sides are 6″ wide. Of course, before our door and windows can be made fast to the brick and stone sides of the openings, the sides must be lined with wood, that is, frames must be made of such a size that their sides shall fit tightly to the sides of the openings. These are "window frames" and "door frames." Remember the names, as these are almost as common as A B C's in buildings, and architectural drawing. And remember why they are needed; not to make part of the wall, but so that sliding sheets of glass, and swinging doors, may be tightly secured to their sides.

To represent these frames on our drawings, draw lines around the two sides and top of our door opening, 2″ from them; and

across the bottom, ¼" from it; these represent the wooden frame. The frame of which the swinging door is made is drawn as in Fig. 92. Draw this. The frames for the windows may be shown practically the same as the door frame; that is, 2" on all four sides. The space for each window opening is filled by two sheets of glass, as in Fig. 93. Complete your windows very carefully, using this sketch and the figures as a model.

If, to each end of this wall there is supposed to be joined a wall going directly back from the observer, and the further ends of these two walls joined by a wall like the front, it is clear that from our single brick at the corner, there has grown up a complete building.

It will be a very simple matter now to build four brick piers along on top of our wall, beginning at the stone course. Their sizes are exactly the same as the first ones (except their height), and they are exactly above them. Their height is thirty-three courses, beginning at the top of the stone course. Draw these, as before, four to every 10" of height; or twelve to every 2'-6". Then, along the tops of these, show, lightly, the front edge of a floor, exactly as before.

Next, on top of these four piers (beginning at the tops of the piers; not the floor) draw four more piers forty-eight courses high. On top of these show the front edge of a floor, as before (though in this case, it will be a flat roof). Finally, continue each pier upward eighteen courses, making the outside ends of the sixteenth, seventeenth and eighteenth courses of piers 1 and 4 to project as in Fig. 94.

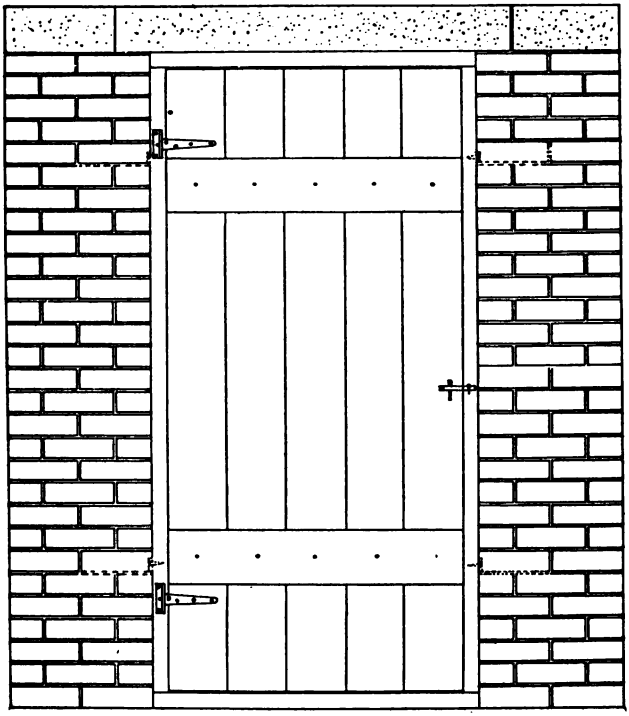
The piers in our second story are thirty-three courses high to the under side of the third floor. From the under side of this floor, count down three courses to the tops of the stone lintels for the second story windows; they are the same as those in the first story. Draw them in, dotting their surface as before. Next, erase the six vertical sides of the piers which form the openings above the lintels, and draw sixteen courses of bricks in the space over each window lintel, so as to make the courses run the entire width of the wall. Then, on top of these courses, draw three more stone sills for the third story windows, exactly the same as those in the first story.

If the three windows for the third story are twenty-six brick courses high, from the tops of the sills to the under sides of

the lintels, complete these windows. Draw brick courses on top of these window lintels, as high as the tops of the piers, erasing the vertical lines at the sides of the openings as before. Along the entire length of the wall show a stone coping 5″ high, projecting 2″ beyond the ends of the topmost course of bricks, as in Fig. 95. This forms a very simple example of a cornice. Cornices will be spoken of in detail later. This particular form of cornice is called, "corbelling"; the brick courses extend beyond those below them, like steps, upside down.

Complete this elevation by drawing the six frames for the six window openings; then the six pairs of double hung sash, as in the first story. Dot the faces of all stone beams, as sills, lintels, copings, etc. The title for the drawing should be drawn just above the bottom border line, and directly in the center, as in Fig. 96. "Plate 18," in letters 3/16″ high should be drawn ½″ below the top border line. Ink in carefully the whole drawing, brick courses and all. Erase all pencil marks, and clean the sheet with a soft eraser.

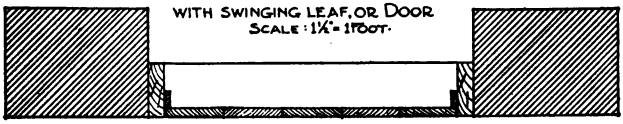
PLATE 19.



GARDEN WALL OPENING

WITH SWINGING LEAF, OR DOOR

SCALE : 1¼" = 1 FOOT.



TOP VIEW

PROBLEM XIX

(See Plate 19)

We have seen how walls are built, and it would really not be a very difficult matter to build a brick garden wall, about six feet high, enclosing the four sides of a plot of ground. In one of these sides, just imagine a piece of wall 3'-0" wide cut right out, thus leaving an opening for passing in and out. To make it secure from strangers walking in, a frame made of a few pieces of wood or iron, could be hung on two rods, driven into the mortar joints at one of the sides of the opening; the other edge of the frame could be fastened in a similar way, and latched. If we should want to make it impossible for anyone to *see* through the gate, then we could make a frame of boards fitting tightly together, and secured to the sides of the opening just as before. If we wished to close up the cracks between the edges of the frame, and the sides of the opening we could nail a strip of wood to the mortar joints; one on each side of the openings, as in Fig. 97. If the wood strip is desired to be stronger, then it would be necessary to use stronger nails to fasten it to the edges, or even strips of iron screwed to the back of the strip and built into the bricks; these are called "anchors." Another anchor or dowel fastened to the lower end of the strip and let into the sill helps greatly to hold it in place. If we make the wooden strip large and strong, securing it tightly by anchors, or by wooden blocks, built right into the brickwork, then we can fasten our gate directly to these pieces by hinges, as in Fig. 98, and then nail another little strip to the bigger strip to close up the crack and to act as a stop. The size of the large piece of wood is $1\frac{1}{4}$" thick and about 6" wide; that of the smaller is $\frac{1}{2}$" thick by 2" wide; one is called the "jamb"; the other the "stop bead."

The gate (we may call it a door now), swinging on its hinges, causes quite a pull on one jamb, and if this jamb could be joined with the opposite jamb, it would be greatly strengthened.

Just run a third piece of wood across the top and nail its ends to the upper ends of the jambs, as in Fig. 99. Run a fourth piece across the bottom and it will serve to make them perfectly secure. This piece which we find at the bottom, we call the "sill"; a little piece nailed to the top of this, the "threshold." The cross-piece at the top is the "head"; or the "yoke," if it's at the top of a window opening. The two cross-pieces and the two uprights joined together firmly are a frame; if for a doorway, a "door frame"; for a window, a "window frame."

In order to fix this subject firmly in mind, the following interesting problem is given: Tack a sheet of paper 11"x 15" in a vertical position to your board. Draw the border lines; also a vertical center line. 3½" above the bottom border line, draw a light horizontal line across your sheet (see Plate 19). Let this be the ground line. On this, draw at 1½" scale, 1'-6" to the left of the center line, the front view of a brick pier 16" wide and twenty-nine courses of brick high, each course being 2½" high, as in Fig. 100, the mortar joints being ½" thick.

The top view, giving the thickness, 12", should be shown ¾" (actual) below the front view, as in the figure. Next, 3'-0" to the right of the front view, draw the front view of another pier of the same size. The piers might be also the ends of walls stopping at each side of the opening. The space between these two piers, or posts, or wall ends, is to be filled by a "leaf" of boards held together by two cross-boards nailed to them to make them fast, as in Plate 5. This "leaf" is simply five boards placed edge to edge, like boards in a floor, and two boards nailed across them to hold them together.

Draw, on the front view, a vertical line 1¾" (to scale) from the right side of the left pier, stopping when it gets to within 1½" of the top and 1¾" of the bottom; do the same on the left side of the other pier. If these are the front views of planks, which are anchored to each side of the opening, show their top view, their front face being flush with the front, or near face of the piers, and their width being 6". Show the anchor for the top of the left hand plank as in Fig. 101. Show the same on top of the sixth course of bricks up from the bottom. The plank is now tightly secured to the side of the brick pier. Show the other plank secured to the right pier in the same way; draw the screws and anchors carefully. Show also the front

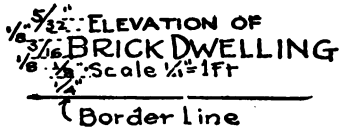
view of 1¾" cross-piece at the top of the opening, resting on the upper ends of the two uprights, and nailed to them; show the same at the bottom of the opening and nailed to the bottom ends of the uprights, as in Fig. 102.

As we have seen, the space inside of this frame is filled by a "leaf" of five vertical boards of the height of the opening, each being one-fifth its width and placed edge to edge. These are held together by a 6" cross-piece 10" down from the top, and the same sized cross-piece 12" up from the bottom. Construct the door, as in Fig. 103. Draw a hinge just above the top cross-piece, as in Fig. 104. Draw one also just below the bottom cross-piece. These secure the door to one side of its opening. Show nails joining the cross-piece to the boards. The other edge is secured by a latch, drawn as in Fig. 105, its upper edge being 3'-0" above the ground line. As the boards in the door are now, there will be cracks between them, especially if the wood shrinks. To prevent this, the edges are cut with ledges in one edge, and grooves in the other, that is, "tongued and grooved," as in Fig. 106.

To complete our top view, finish the top view of each pier, directly under the front view of each, as shown in Fig 100. Then show the top view of each jamb, anchored to the side of the piers, the top view of the wooden sill across the top (the bottom would be just the same), the stop beads, and finally the door itself, as in Fig. 107. The cross-hatch lines for the brick piers should be drawn at an angle of 45°, and 1/16" apart. Cross-hatching for the wood should be wavy.

The work of closing our opening is now practically completed. The wall, itself, at the edges of the opening; the frame with which it is lined; the door which fits into this frame; the hinges and latch which join door and frame together; the anchors and nails and cross-pieces—these are all fully and explicitly shown. It but remains to show a stone across the top of the wall opening, 5" high, and resting 4" on the edge of each pier. The remainder of the pier should be shown covered by the same height of stone.

Ink in with India ink, and do not be satisfied to have your drawing look like anything less than a printed plate. ⅜" (actual) below the front view draw the title "Garden Wall Opening," making the letters 3/16" high, and the capitals a little higher. 5/16"



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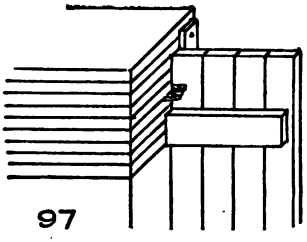

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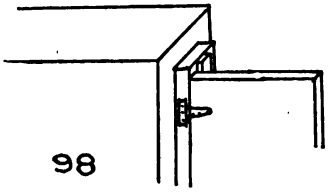

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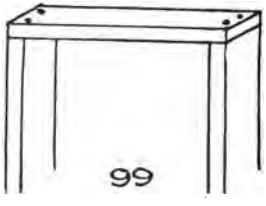

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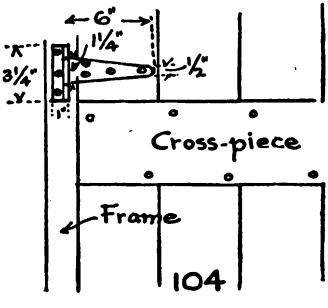
Top View



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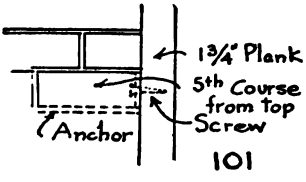

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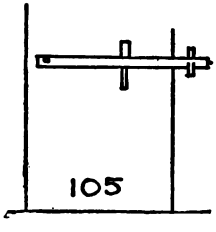

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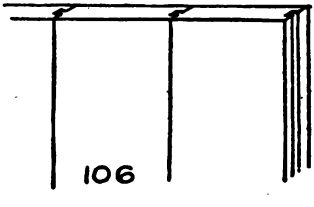
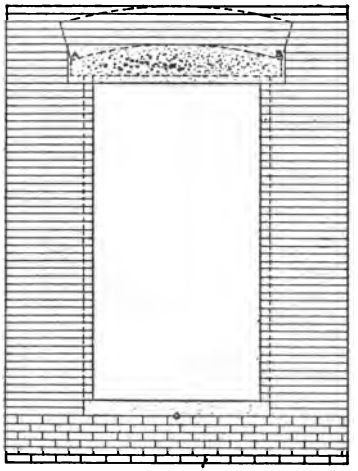


106

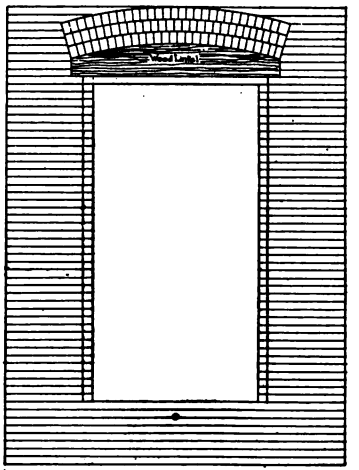
below the top view draw the title "Top View" with letters 3/16" high, and capitals a little higher. This finishes the plate. This particular form of opening holds in its simple make-up all the indispensable parts that are found in the great multitude of openings the world over. There is hardly an opening anywhere that does not have two upright edges, or jambs, a bottom and a top edge, or sill and head; and there is almost no wall opening but is enclosed by a sheet of some kind, or other, whether thick or thin; wood, or glass, or metal. The two piers in the plate might have been solid stone, or a number of blocks of stone, or wood, or hollow iron posts; or they might have been twice as high, or twice as far apart; and the front might have been some beautiful brick design, or faced with terra cotta or stone blocks; yet the idea of the four sides would not have been changed in any way. The same with the lining of the edges, or frame; one or the other face of it might be moulded, or a moulding nailed to it at the edges where it fits against the walls; or a groove might be cut out of it all the way around it for the door or window, screen or shutter to fit into it; yet the four sides remain. The sheet which closes the opening will always be very thin compared with the wall; all it has to do is to swing or slide or turn, while the wall has generally a great weight to carry. As for the fastenings, hinges are still used, though very often in the form of the butt hinge; the latch, or fastening part, takes a great many forms, from the hook up to the knob latch, the bolt, chain and so on.

PLATE 20.

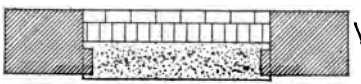


·OUTSIDE VIEW· 1·

·VERTICAL SECTION· 2·

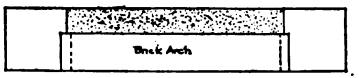


·INSIDE VIEW· 3·



·HORIZONTAL SECTION· 4·

DRAWINGS OF
WINDOW OPENING
IN BRICK WALL
SCALE ¾"=1 FOOT



·TOP VIEW· 5·

PROBLEM XX

(See Plate 20)

We have seen that an opening, that is, a wall opening, consists practically of two posts about three feet apart, with a cross-piece resting on their upper ends. At the bottom is generally another cross-piece which is usually just the top of the wall that is stopped for the opening. It is plain that if we study these four parts, (the two uprights and the two cross-pieces) so as to get absolutely familiar with them, then we will understand the openings thoroughly. Let us begin with one of the uprights. The very simplest form is that in which all sides are perfectly square; the front side A, (Fig. 108), the side, B, and the rear side, C. In New York City, these are found in great numbers in the oldest part of the city, the down town district. Imagine the front edge between A and B planed off, and we have another simple form, as in Fig. 109. Call this narrow surface, D. Now, D might be made a curved surface, in or out (concave or convex); or it might be a double curve; in fact, there is scarcely any limit to the way in which it might be treated and beautified. If, instead of the surface D being on the slant, it were made like a groove (rebate), it would appear as in Fig 110. Most sides of openings in masonry walls are made in this way for the frames to fit snugly into. Fig. 111 shows another arrangement of rebates, the edge of the front one being rounded off. This round surface very often is a column, or other architectural feature. The surface A, may be a single long stone, or a number of blocks of stone, or blocks of terra cotta, or bricks, etc.; and the arrangement of these in color and shape is without number. The surface, C, being at the inside, is generally covered with plaster. Don't forget these three surfaces, A, B and C, as they will be spoken of quite frequently later. The very greatest benefit, in the study of openings, may be obtained by studying the A, B and C faces of a large number of window and door openings of various buildings. This

method is recommended, rather than a study of design in books. It increases our powers of observation and gives an idea of the scale of details.

The bottom edge of the opening, in its simplest form, is perfectly square, just as the side is, as in Fig. 112. (The A, B and C of the top will be spoken of later.) Then the edge A B, or B C may be cut off to form a sloping surface, as in the case of the upright side; only, here it is a case of *must*, on the outside edge, so that the rain water may be shed off. In cellars, the inside edge is often sloped to allow all the light possible to reach the cellar floor. In brick walls, this bottom edge of the opening is always covered with a long flat stone on the *outside* edge. Name this stone. Answer: Sill. The inner half of this edge will be spoken of later.

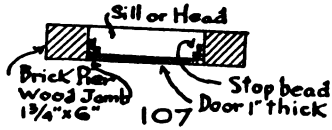
There remains only the top side of the opening; and, as in the other cases, the simplest form of this is a solid piece of stone, cut square, and long enough to rest on the pier at each side of the opening. The edges of this may be bevelled, rounded or rebated just as in the other three sides—only, as this member must carry a heavy load, and is only supported at its extreme ends, the more it is cut away, the weaker it will be. Again, the cross-piece might be, instead of square in section, rectangular, and laid either flat or on edge. In frame buildings it is wood. If it were iron, it would be comparatively thin.

Keeping this in mind, the student should get a piece of cardboard, like the back of letter pad, and make the following experiment: First, place it flat on the table; it will need no experiment to find that even a very great weight will make practically no impression on it; but, if the ends, alone, are allowed to rest on supports, such as a book at each end, the load would break it in two. Next, if, placing the cardboard flat on the table, the ends are pushed toward each other, so as to cause the card board to bend up in a curve, about an inch high at the middle, it will be found to be very stiff and able to support a considerable weight, even though it rests on the table only at its extreme ends. The last case is that of the bent cross-piece; we have just seen how much greater its strength is than the flat cross-piece. In almost every case where the top cross-piece is bent or curved ("arched") it is made of a number of small blocks (bricks, or stones) fitted together and their joints filled

with mortar. If these blocks are of stone, they are cut like wedges, called "voussoirs." The top cross-pieces of nearly all ordinary brick wall openings are made up of both a flat and a curved cross-piece; the flat one of stone at the outside face of the wall, and the curved one of bricks at the inside face. The stone cross-piece is only 4" thick from front to rear and is more for show, while the arch of brick on the inside does the work; it is not made at all for looks, being always covered over and hidden by plaster.

Fig. 113 shows No. 1 and No. 2 "cross-pieces," No. 1 being the flat, and No. 2 the curved. Note that the side is arranged with the rebate. Note also that the curved cross-piece, or arch, supports the greater part of the wall over the opening. In a great many modern buildings, instead of the arch, horizontal cross-pieces are used, of a shape very similar to ordinary railroad iron, called an I-beam, as shown in Fig. 114. It is made in this shape, because it is the strongest and most useful. As we have said before, flat sheets of iron are also used. Wood beams are used under the inside brick arch ("relieving arch") but merely for nailing the inside "finish" to. For examples of the A and C faces of the top side of openings, students should make sketches from the heads of openings, themselves.

Having made this general study of each of the four sides of wall openings, especially the openings for light and air (windows), we are ready to construct a large one on paper. Tack down a sheet 15"x 22", placed horizontally. Draw border lines, ¼" for the cutting line, and ½" inside this for the finished border line. Draw the front view (see outside view, Plate 20) of six courses of bricks laid on top of each other, their bottom line being 3-11/16" above the lower border line, and their left ends being in a vertical line 1" from the left border line. Scale ¾"=1 ft. Each course is 2½" high, counting half the mortar joint on each side of the brick, 9'-2" long from left to right, and 20" from front to rear; show the joints only in a single line. This last dimension, of course, cannot be seen on the front view. Divide the bottom course into 8" lengths by short vertical lines. Divide the third and fifth courses in the same way. Divide the second course, and also the fourth and sixth courses so that their vertical joints will come over the middle of the bricks below.



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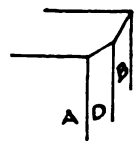

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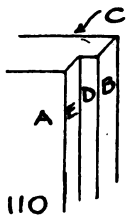

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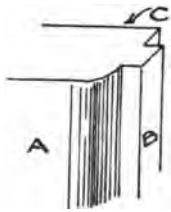

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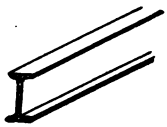
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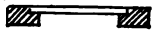
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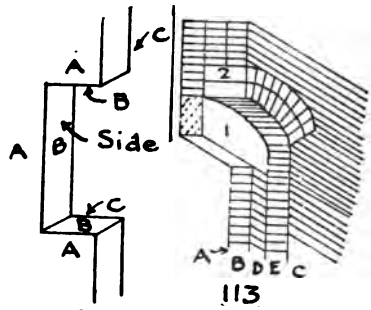

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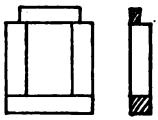

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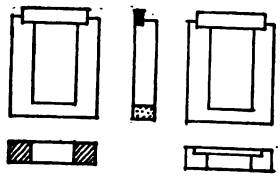
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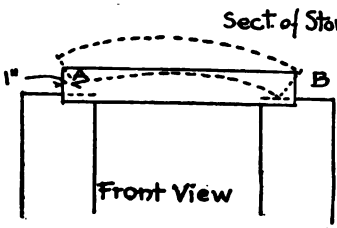

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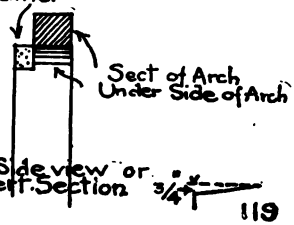


119

On the left hand end of this brick wall rests a brick pier 2'-4" wide (20" thick) and forty-three courses high. It is made up, then, of forty-three layers, placed one on top of the other, four to every 10" in height, making the total height 43 multiplied by $2\frac{1}{2}''=107\frac{1}{2}''=107\frac{1}{2}''\div 12=8'\text{-}11\frac{1}{2}''$. The cracks between the layers may be shown by a single horizontal line. Do not show the short, vertical joints, as it takes too much time.

Leaving a space of $1\frac{1}{4}''$ (actual) to the right of the lower six courses of brick (not the pier) draw the left end view of this low wall. This will be merely a horizontal rectangle six courses high and 20" wide. Continue its vertical lines up the height of the pier to give the side view of the pier. $1\frac{1}{4}''$ (actual) to the right of the end view of the low six course wall, draw the rear view of the same showing the brick joints. At the *right* end, on top of it, draw the rear view of the pier of which we have already drawn the front view, showing the brick joints.

Now to the outside view again. $1\frac{1}{4}''$ (actual) directly below the front view of the bottom six course wall, draw the *top view* of it (see horizontal section); this will be a horizontal rectangle, the same length as the front view and 20" wide. A vertical line drawn across it at the left end just below the inner edge of the pier in the front view will give the plan of the pier. By cross-hatching this end space, it will show that there is an upright pier there. Would the space alone, without the cross-hatching, show that? No. At the right hand end of the sheet, directly under the rear view, draw a second top view; in this case the pier will be shown at the right end of the low wall. This makes five views of our wall and pier; the sixth, or under view, need not be shown. We shall add many parts to these.

First, let us number our views from 1 to 5, beginning with the outside view, No. 1; No. 2, the side view, or vertical section; No. 3, rear view, or inside view; No. 4, top view, or horizontal section; No. 5, upper top view, or top view, the last one which we have drawn. Add first to No. 1, a second pier at the right end of the wall, the same size as the first. This we will not show on No. 2, as in doing so we would hide the pier which is already shown there. In No. 3, the rear view of it will be shown at the left hand end of the low wall, drawing also the brick joints. In No. 4, it will be shown at the right hand end; in No. 5, at the left hand end.

The space between the two piers is 4′-6″ wide; therefore if we place a stone which is 16″ longer than this width so that the ends rest equally on the piers at the top, the stone will be 4′-6″ plus 16″= 4′-22″= 5′-10″ long. If this stone is five courses high (5x2½″=12½″) draw the same in its proper position in No. 1. Looked at from the right side or end, it will be seen to be 8″ thick. Show then this end view in No. 2 on top of the pier at the left hand edge; it will be a vertical rectangle 8″ wide, and the same height as in the front view; see Fig. 115. Draw this also in No. 3, but dotted. No. 4 is supposed to be the top view of only the *bottom* part of the piers and wall, so the stone cross-piece is not shown in it at all. But it is, in No. 5, as shown in Fig. 116.

Look at No. 2 for a minute; it represents, at the bottom, the end of the low wall; connected to the top of that is the side of the pier resting on the left end of the low wall; and, on top of this, at the left side, the end view of the stone lintel; three parts, the fourth one not being shown. The view is exactly the same as if we should pass a big saw right down through the top stone in the front view, across the opening between the piers, and the wall at the bottom, and then make a drawing of it all, looking at it from the side. No. 2, then, will be readily recognized as a section; and as the cutting is done in a vertical direction, it is a vertical section. Plate 16 is a vertical section, but of a whole building. Again, in No. 4, of our present plate, if we can imagine a saw passed sideways right through the two piers and across the space between them, a short distance above the bottom wall, and a drawing made of this sawed surface, it would be the same as that we have now. Which section would this be? Answer. Horizontal section. No. 5 we may take as a top view, or plan, of the tops of the piers and whatever may be placed on them.

Next, show on view No. 1 another course of brick added to the top of each pier, covering, of course, the whole top of the piers, except where the stone ends rest on them. Show the side view of this carefully in view No. 2. Also the rear (No. 3), where it is shown the entire width of the pier; dot the portion of the stone ends which the bricks hide. Erase the last top line of the piers in views Nos. 2 and 3.

Fig. 117 shows in a small way just how each of the five

large views should look on our drawings now. They must be exactly right, up to this point, so that it may be possible to add the parts which are to follow.

The stone lintel in No. 1 goes back only 8″ so that there is still 12″ not yet spanned. This is to be spanned by a curved cross-piece made of bricks; that is, an arch, just 12″ from front to rear. To find just where this arch will come, place the needle of your large compass exactly at the middle point of the bottom line of the opening O (in the upper edge of the bottom wall), and with the pencil point at the middle point of the top line of the lintel, draw a dotted curved line first to the left, and then to the right, stopping it 1″ (to scale) inside of each end of the lintel. Mark left end A; right end B. From each end of the curved line, draw first, a short dotted line vertically down till it reaches the extreme top line of the pier; then from A draw a slanting line up to the left, 12½″, by placing the lower edge of a long triangle at O and the upper part of the edge at A; our slanting line is to be drawn along the edge of the triangle above A. Draw the same at B. Then if a second curved line, 12½″ above the lower curved line, is drawn, with O as a center, stopping at the two slanting lines at the end, as in Fig. 118, our arch lines are finished.

Show the arch added to the vertical section as in the figure; also draw the same carefully in No. 3; also No. 5. In No. 3, the space under each end of the arch has been left for the end of a beam to rest on the corner of each pier, and whose upper edge is cut so as to fit exactly the under curve of the arch; the face of this is flush with the rear face of the piers; it is 3″ thick. Back of it a space of 3″ is left, then another beam just like the first one is placed behind it. This, of course, will not be seen in view No. 3, but will be in the vertical section. The arch in No. 5 will hide the sides of the opening; erase them. Complete the cross beam (wood lintel) in No. 1. Also continue the brick courses in No. 1 up to the top edge of the stone lintel. Then continue the whole thing five courses higher, including an 8″ thickness on top of the lintel. Show this also in No. 2 and No. 3. Erase the top of the pier lines in No. 3.

At the bottom of the opening in No. 1, draw the front view of a stone beam two courses high, resting on top of the bottom wall, and 3″ longer at each end than the width of the opening,

that is, so that it fits into the side of each pier 3″. This stone must be placed here so as to act as a cover to the mortar joints between the bricks, and shed the rain-water off them. The reason for running the ends into the piers, instead of stopping them at the sides of the piers, as in "slip" sills, is to secure them firmly in place. The front edge of the sill always sets out beyond the face of the wall so as to cause the water to drip away from the wall. But this cannot be shown in No. 1; only in No. 2. Draw the end view, or section, in No. 2, with the left edge projecting 1½″ beyond the wall line, and the depth of the sill, from left to right, 12″. Show this also in the rear view, and in No. 4. Dot the ends where they are hidden by the brick work. In No. 2 show the space back of the sill filled with brick to the top of the sill; the same in No. 4. The slope of the top face of the sill for allowing the water to flow off will be explained later.

What have we done? We have constructed out of brick and stone, walls and piers so as to form an opening; in this case, a window. If we will look at the A, or outside, face of the left upright in No. 1, we will see that it is perfectly square; so is that of the right upright; it consists, in each case, of the ends of the rows of bricks. The B face, or side, of the piers is also perfectly square; so is the C face in both uprights. The A, or outside, face of the bottom side is also practically square, with the exception of the slight projection of the stone sill; the B face is square; so is the C face. At the top, the A, or outside, face is square; so is the C face, though it includes the faces of the wood lintel and the curved brick arch; yet the surface is square. The B face, or under face is different, in that it shows one part, the wooden lintel part, raised 2½″ higher than the stone part, forming a rebate. The wood lintels (and the relieving arch above them) are placed higher than the under side of the stone lintel for the purpose of allowing the top of the window frame to fit into the space. We will next provide for this same groove in the sides of the piers for the sides of our frame to fit into.

Beginning with the left pier on view No. 1, 3″ from its right vertical edge draw a dotted vertical line from the top of the sill up to the dotted under side of the wooden lintel, which shows through the stone lintel. This shows plainly that there

is a rebate on the sides, as well as at the top; but it does not show how far back it is. Imagine, then, looking at the one in the left pier from the side, and the exact position and size of it may be plainly seen; it will be seen that the front 8″ of the wall project beyond the inside 12″; so that if we draw a vertical line in No. 2 from the right edge of the stone lintel, that is, 8″ from the left edge, down to the top of the sill the view from the side will be represented. In No. 3, the rear view of this rebate may be shown by a vertical line drawn 3″ inside of the inner edge of the piers from the under side of the wood lintel down to the top line of the sill. Show this cutting away of the inner faces of the piers carefully in No. 4; but not in No. 5 as it cannot be clearly shown there.

Looking at Plate 20, we will see that the brick arch in No. 3 is shown divided into three equal arches, and each of these divided again into bricks. This is done by placing the lower part of the edge of a large triangle at the point O at the bottom of the opening and the upper part of it at points on the under side of each small arch, or "rowlock" 2½″ apart, then drawing from each of these points a line upward to meet the other curved line of the rowlock. Be sure to cover the surface of the stone lintel and sill in No. 1 with small dots about ⅛″ (actual) apart. Their sawed surfaces, or sections, should be dotted also, but using some larger dots, too. Dot also the top surfaces in Nos. 4 and 5. Cross-hatch the brick sections in Nos. 2 and 4 with 45° lines up to the right and 1/16″ apart. In view No. 4 show the tops of the bricks in the space between the brick piers.

PROBLEM XXI

(See Plate 21)

As we have before seen, we must have the four sides of our opening lined with wood before it is possible to have windows in them; we have also seen how these four sides are joined together to make a frame. Tack a sheet of bond tracing paper tightly over Plate 20. Do not trace the lines of this plate, until directed. A plank is first to be placed in No. 4, on top of the wall running between the piers; that is, from pier to pier. Its front edge is on the same line as the front of the rebate; that is, 8″ back from the front face of the piers; its rear edge is 7½″ back from the front edge; it goes 1″ into the side of the rebate at each side of the opening; how long does that make the plank? Answer. Width of opening at the front (between the "reveals") 4′-6″; 3″ depth of each rebate, 6″; 1″ into each rebate, 2″; total, 5′-2″. Show the front view of this in No. 1, the height from the top of the stone sill to the top of the plank being 1¾″. Dot the ends where they go into the brick work. In the vertical section, No. 2, we will see the plank as though it were sawed in two; that is, an almost horizontal rectangle 1¾″ high and 7½″ wide, with its left edge setting back 8″ from the outer face of the pier. Draw the left end of this first; then instead of drawing the top line horizontally, draw it so that its right end is ¾″ higher than the left, as in Fig. 119. The plank is placed thus to turn off the rain water flowing down the window panes. The under side of the plank has the same slant as the upper. Finish the section of the sill. Show cross-hatch for the grain of the wood. It is easy to see what the rear view of this will be; imagine yourself looking at this in view No. 2, from the right side. We will see the top edge as a horizontal line; 1¾″ below this, the lower edge; and ¾″ below this the bottom edge at the front where it touches the top of the stone sill. Show the ends, dotted, running 1″ into each rebate. Looking at the sectional view from the left side

we will see the topmost line; draw this in No. 1. The slant will not be shown in view No. 4.

A little fine work will have to be done in No. 4. The front edge of the plank is to be cut out at each end for a board to fit into each cut; the boards standing on end. The cuts should be $\frac{1}{8}$″ deep, and $6\frac{5}{8}$″ long from left to right, as in Fig. 120. Draw these carefully. Make cuts also at the ends of the inner edge, but only 6″ long; these are for the same purpose as the others. The front cuts may be shown on view No. 1; the rear cuts on view No. 3. Now that the lining of the bottom or near, side is attended to, we may arrange for that of the left side, or upright. It is a board with its bottom end resting directly on the top of the bottom plank and sinking into it $\frac{5}{8}$″. The exact spot where it rests on this plank (wooden sill) is found in this way: at the left end of the sill, in view No. 4, draw a small vertical rectangle $1\frac{1}{4}$″ wide and $5\frac{3}{4}$″ long, so that its right side will be just 5″ from the side of the rebate, or 2″ from the side of the reveal. Cross-hatch this for wood, and it will show a board standing in this position. Show the front view of this in No. 1 running up beside the right edge of the pier, nearly to the stone lintel. The side view of this, of course, will be shown in No. 2 by two vertical lines running from the top side of the section of the wood sill to nearly the under side of the wood lintels; these lines, of course, will be $\frac{7}{8}$″ in from the two end lines of the sill section. The rear view will be the same as the front, except that it is at the right side of the opening. The upright at the right side of the opening is shown in No. 4 just as it was on the left side, the same distance out. Draw this in views No. 4, No. 1, and at the left side in No. 3. These uprights are stiles, "pulley stiles," named so on account of the pulleys at their upper ends. Next, across the top of the opening in view No. 1 show a flat board $\frac{7}{8}$″ thick, and its under side 2″ below the under side of the stone lintel; it rests directly on top of the two side uprights and is nailed to them. Grooves are cut in the under side of this cross-piece, or yoke, for these ends to fit tightly into. This cross-piece also extends into the wall an inch at each end, like the wood sill. The cross section of it, or end view in No. 2, shows it the same width as the upright pulley stile, thus making it a narrow horizontal rectangle $\frac{7}{8}$″ high by $4\frac{1}{4}$″ long. Show it also in view No. 3.

In designing window frames, or door frames, these are the first and most important things to think about. Learn each part absolutely, by name, and draw these parts from memory at a smaller scale, until you *know* them. Architects say that window opening and window frame details give draughtsmen more trouble than any others.

Draw a light vertical line directly down through the center of view No. 1; also No. 3. Please follow carefully the following instructions: In view No. 4 at the left hand end, draw a *horizontal* rectangle 1-15/16"x 2¼" so that its left side touches the right side of the pulley stile, and its upper, or further, side is 2¼" from the upper side of the sill, as in Fig. 121. This is the place where a wood upright is to be placed which slides up and down the pulley stile. Show the grain of the wood. Draw the front view of this in No. 1 carrying it up to about the middle of the opening. Draw the side view of the same in No. 2, showing the right line 2¼" to the left of the right edge of the sill section. Draw the rear view in No. 3. Return to the view of this in No. 4; attach to the right side of this small rectangle a long horizontal rectangle 1-5/16" wide and extending to the right to a point half way between the two pulley stiles. This rectangle represents a piece of wood, resting right on top of the wood sill and nailed to the end of the upright, so that they will both slide up together. The flat one, of course, goes all the way across the opening, but for the present we will show only half of it. Show the front view of this in No. 1 making it 4¾" high; draw a sectional view in No. 2, on top of the sill section. Also on view No. 3.

The names for these two pieces which move up together are: the upright sash stile; the horizontal member, the bottom rail. Find a point on the vertical center line across the opening in No. 1, which is 3'-8½" above the top line of the bottom rail; draw a horizontal line from here to the left to the side of the upright sash stile; 1¼" above it draw another horizontal line. Cut off the top of the sash stile on this line. This rail, "the meeting rail," is joined to the upper end of the sash stile. Show the section of it in its proper position in view No. 2; in No. 3. This is not shown in No. 4, being too high for it. In No. 3, now, continue the left line of the sash stile up until it meets the under side of the yoke; joining its left side at its upper end

show a horizontal rectangle 2¼" wide with its top side against the yoke's under side, and extending as far to the left as the vertical center line. There is also a bottom rail (meeting rail) for this top sash, or frame; but it is hidden in this view directly behind the meeting rail of the lower sash. In view No. 2, the section of this second meeting rail is exactly to the left of the first section. In view No. 1, this second meeting rail, of course, will be directly in front of the one which we now have there; simply continue the lower line of the first one as far as the pulley stile. Draw the upper sash stile up to the yoke. Continue the top rail 2¼" wide to the center line of the opening. Show the sectional view from the meeting rails up to the top, as in Fig. 122. These are not all the pieces of wood which go to make up the frame and sash for a window, but they are the most important. The right half of the opening has been left unfinished on purpose; the left side is to be left in the rough, but we will finish the right side.

Draw the right half of the bottom rail and the right sash stile in views Nos. 4 and 1, as shown on Plate 21. Show the little rebate in the sash stile at 6 in view No. 4. This is the edge that is rebated for the glass to fit into. Show the glass by a single line at the front of 7. The other horizontal lines simply show the moulding of the bottom rail; the little rectangle at 6 shows the parting bead head 6B, for separating the inner from the outer sash. The outer sash stile, above, may be shown dotted. No. 8 shows an upright board fitted into the notch at each end of the sill; this is the "outside casing"; its use is too clear to need explanation; it laps over the edge of the pulley stile so as to hold the outer window sash in place. No. 9 shows the location of a strip of wood nailed to the face of No. 8 to close the crack between it and the brick reveal. The lower end of No. 8 runs to the very bottom of the wooden sill and is nailed to the face of it; No. 9 also runs down to this point. In view No. 1, draw front views of No. 9 and No. 8; only the edge of No. 8 can be seen. No. 8 runs up, as shown, back of the brick reveal, to the yoke, where it fits into a space cut out at the corner, just like the corner of the sill; it continues up behind the stone lintel a distance of 1½". No. 9 runs up only to a level with the underside of the yoke. Show side views of No. 8 and No. 9 in No. 2. No. 9 is called the "brick mould."

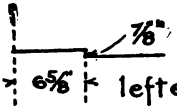
There must be an outside casing which will lap over the edge of the yoke across the top, the same as up the side. Draw the lower edge of this at No. 10 in view No. 1, hiding the yoke, and extending from the vertical center line to the side of No. 8; No. 10 is nailed to the face of the yoke, its upper edge (dotted) being $1\frac{1}{2}$" above the bottom edge of the stone lintel. Draw the brick mould, No. 11, on top of this, running from the center line to the right brick reveal. Nos. 10 and 11 are shown in section No. 2; also No. 12, these, of course, representing the boards coming toward the observer. Looked at from the rear, all this work is hidden; therefore, we do not show it on No. 3. This completes the outside view of the fixed wall frame. Let us show, finally, the movable window sash.

The front view of the left edge of the lower sash stile, No. 6, should be drawn first, from the top of the sill to the under side of the meeting rail. The other edge, of course, is hidden. Draw, next, the front view of the bottom rail No. 7. The upper rail of this sash is hidden directly behind the bottom rail of the top sash. Draw 6A, the stile of the top sash. Draw next the meeting rail, No. 12, in outline. Draw in view No. 1 the top rail, No. 13.

Draw the section of No. 7 in view of No. 2, showing the glass rebate and putty at the upper left hand edge, and the mouldings at the right. Draw the two meeting-rail sections at 12. Draw section of 13; also side view of 6A.

Before going on with the inside finish of the frame, the writer advises the student to study any simple window in a brick wall with its sash and frame, and verify each line on it, and find which number it corresponds to; also name each separate part; such as the pulley stile, sill, yoke, brick-mould, outside casings, parting bead, meeting rails, bottom and top rails of sash, rebate for glass and putty, also points for glass.

Look now at the inside or rear view of our opening, No. 3, and with a little thought we will see that it is not finished. The outside of the wall is finished by a layer of finish brick, or, in many cases it might be a layer of stone blocks, or terra cotta. But the inside is finished almost always with a paste ("plaster") which can be spread smoothly over the entire surface and in any thickness required, like a soft and delicate concrete. Generally, however, the plaster is not spread directly on the face of



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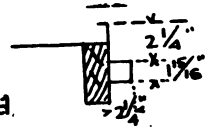

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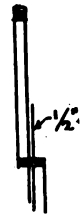

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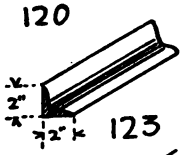

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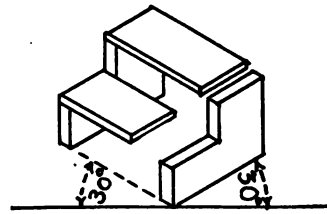

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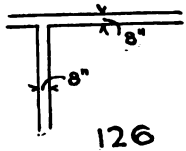

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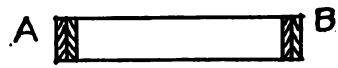

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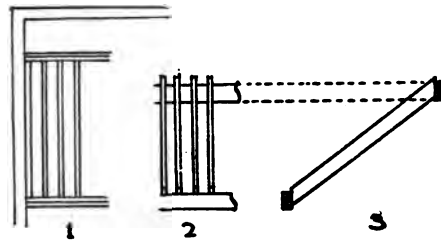

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the brick, but on a thin layer of sheet metal ("furring") with holes in it, which is nailed to the brick, and the plaster spread over it; or, instead, strips of wood and laths may be used, except in fire-proof work.

On the inside of our wall, however, we are to nail (to the mortar joints) rows of flat hollow cakes of terra cotta, 2" thick, 12" wide, and 16" long; these are hollow, and whatever water makes its way through the thickness of the brick wall runs down through the hollows of the blocks, and does not reach the plaster. The whole of the inside of the brick wall around the opening in view No. 3 will be covered with these flat blocks, but we will show only the right half covered; that is, all to the right of the vertical center line. Draw, then, on our tracing paper, the blocks as shown on Plate 21, beginning at the bottom wall; then the right pier; when the top is reached, draw the dotted lines across the top of the opening; these represent a bent iron plate which is placed here to take the weight of the blocks which must cross the opening. The shape of the iron is shown in Fig. 123, and is called an "angle iron." On the left side of the view, the blocks do not show, as they are entirely hidden by the plaster. But let us first finish the half we have begun. Looking at it from the left side we will see the edge as shown in No. 2; the portion which crosses the top on the angle iron is cross-hatched; so is that crossing at the bottom. Note the same effect on view No. 4. Draw this. Show next the terra cotta blocks covered with plaster as at 14, in views No. 2 and No. 4. Next, let us complete our frame. Our sill is in place; so are the two pulley stiles, the yoke, the outside casings, parting beads, window sash and glass. In view No. 4 is shown the upper right hand cut in the sill filled with an upright, No. 15, called the "inside casing"; this has the effect of closing the space between the pulley stile and the brick wall on the inside. A fourth upright, No. 16, is shown resting on top of the sill with its back directly against the side of the brick opening; this is the "back lining" and makes, with the other three uprights, a box in which the window weights hang, for holding the sash firmly in place, when they are raised. The top views of these weights are shown. No. 17 is a ½" strip ("stop bead") fitting into the face of the pulley stile to hold the inner sash firmly in place. Draw it. The only other view

of this which need be shown is in No. 3. The pulley stile on the left hand side of No. 3 will be covered by the stop bead and the inside casing. Draw the rear view of No. 17 in No. 3 running from the top of the sill to the under side of the yoke. Show, also, the inside view of the sill raised $\frac{1}{2}''$ higher so as to form a rebate for the sash to fit into; see No. 18. At the top, show No. 19, 4″ wide, nailed to the inside edge of the yoke, and its lower edge on the same line as the lower edge of the yoke. It runs from the vertical center line to the edge of the brick opening. Show section of this, $\frac{7}{8}''$x 4″, at No. 19, view No. 2. No. 20 shows a $\frac{1}{2}''$x $2\frac{1}{4}''$ stop bead nailed (or screwed) to the under side of the yoke and No. 19. The upper and lower sash may now be shown on view No. 3 taking care to allow only $1\frac{3}{4}''$ of the stiles to appear outside the stop bead. Next, erase the two lower sill lines in the left half of view No. 3, as they are to be hidden by strips which will be placed in front of them. Show the front view of a $\frac{7}{8}''$ board, No. 21, laid flat with its rear edge fitting tight against the inside edge of the sill. The top of it is just $\frac{1}{2}''$ below the top of the sill, and a tongue along its edge fits into a groove all along the inside edge of the sill. This board is the inside sill, or "stool," and is needed to cover the rough edge of the brick opening along the bottom. It extends to the left 4″ beyond the edge of the brick rebate. Its width at the middle is shown on view No. 2. In view No. 4, it is shown projecting $1\frac{1}{2}''$ beyond the face of the plaster; its right end stops within $\frac{1}{2}''$ of the brick, and a little corner projects around the edge of the plaster so as to give a little shelf for an upright to stand on. Under the front edge of the stool is shown a strip $\frac{7}{8}''$x $2\frac{1}{2}''$ fitting against the under side and flat against the plaster. The side view is shown in No. 2.

As we saw that the sill when it reached the inside, became the stool, so the yoke has also an inside portion. 3″ above the upper edge of the top stop bead, No. 20, is the under side of this piece, No. 23, $\frac{7}{8}''$ thick; the upper side is hidden, so there is no need of showing it. The section of No. 23 is shown in No. 2, extending from No. 19 to the face of the plaster; it need not be shown in No. 3. We will see by looking at view No. 4 that there is still part of the sides of our window opening not covered. Referring to Plate 21 we will see on view

No. 4 that there is an upright $\frac{7}{8}$" thick (No. 24) placed near the brick rebate, 3" to the right of the left edge of the inside casing, No. 15; its front edge is tongued into the side of the casing, and its rear edge is on a line with the plaster. It is called the "jamb casing," from the name "jamb," which is the common name for the upright side of a window or door opening. The upright view of this, of course, would be shown in No. 3 at the left side; half of the side view is shown in No. 2. Finally, show in view No. 4 the end of an upright, No. 25, $1\frac{1}{8}$" thick and 5" wide nailed to the edge of No. 24, and covering the edge of the plaster. This is called the "trim." It is generally moulded, instead of being left square, as in Fig. 124. Its upright view is shown in No. 3, resting on the end of the stool; its upper end is stopped by the top trim, No. 26 in view No. 3. Draw No. 26 in both views; also side view of No. 25 in No. 2. Finish carefully all other parts as shown on the plate. Then ink in with water-proof ink.

The student is advised to complete the drawing of the bricks and stones on Plate 21, thus showing the window exactly as it will appear when finished.

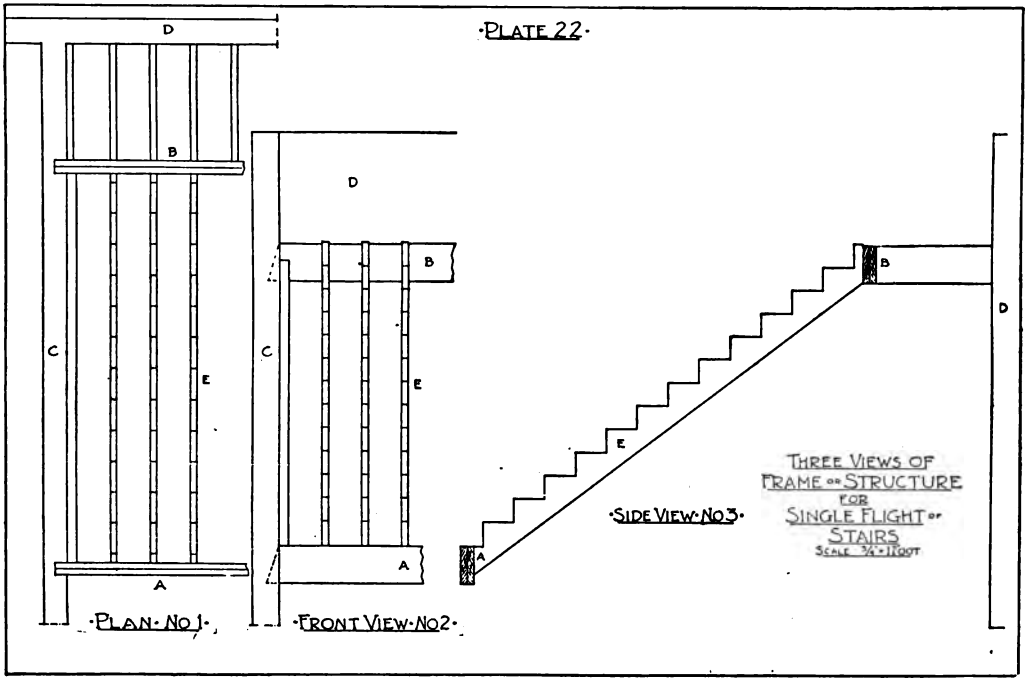


PLATE 22
D
B
C
E
A
PLAN NO 1
D
B
C
E
A
FRONT VIEW NO 2
B
D
E
A
SIDE VIEW NO 3
THREE VIEWS OF FRAME OF STRUCTURE FOR SINGLE FLIGHT OF STAIRS
SCALE 3/4" = 1 FOOT

PROBLEM XXII

(See Plate 22)

We now arrive at the point where we are ready to study a structure for the inside of our building. Up till now we have been learning how the three sheets—floors, walls and roofs, as well as openings in the second, walls—are made. These openings (doors, windows) as we know, are for allowing light, air and also objects to pass in and out. We must now think about openings in floors, for allowing these same things to pass from one story to another, or from one floor to another. We will take *stairs* and the openings for them first.

These are invariably more or less of a puzzle to the young draughtsman. In actual life they have so much of their construction hidden, that one needs to see with X-rays, to be able to take in at a glance all the parts of a single stair-case, not to mention making complete drawings of them. But if it is so difficult to learn all the parts, and the use of them, etc., of a single set of stairs, how almost impossible it would seem to be able to know and understand all the stairs in the world that have ever been made. Yet, they have each and every one been made for the single, simple reason that somebody needed to get from one height to another; or as we may think of it, from one level floor, or platform, to another, down or up. Name an instance of a single step for joining two floor levels. One step is the usual height of a store floor above the sidewalk. From four to eight is the usual number for joining the ground level with the porch level in country houses. Sixteen is the average number connecting two floors of a building.

Imagine a low platform, about 6″ high, in the middle of a room. The edge of it, if strong enough to support the weight of one or more persons, is a step. But if it should be over a foot in height, it could not be called a step, being too high for the ordinary lift of a person's foot. In this case, if a block of wood should be placed on the floor just below the edge, the

two steps thus provided would make a very easy means for reaching the top of the platform.

Now this single block of wood is the key to the whole question of steps; it has in itself just what we need to accomplish our purpose—strength, suitable height above the floor, and width and length on top. The height should be between 6″ and 8″. The width on top, in order to accommodate the foot well, must be somewhat less than a foot; the average is 10½″. The length, if for only one person, would have to be about two feet; but as steps are always made to allow two persons to pass each other on them, the ordinary width is 3′-0″.

These facts apply to all blocks used for steps, whether they are wood, stone, iron or other material. The step may be hollow within provided it is flat on top and has vertical edges; but it must be sufficiently strong. Therefore, it may be a box.

The top face of the box must be the strongest; it is usually a piece of wood 1⅛″ thick, and is called the "tread"; the front vertical edge ("riser"), is ⅞″ thick.

If our platform is, let us say, 3′-0″ high, the edge, if not protected somehow, will be a danger point; therefore, it will be well to have posts with a rail on top to form a sort of wall here; the ends of the steps too, should have the same means of protection. The rail in this case is called the "hand-rail"; the bottom post, if larger than the others, is called the "newel post."

Where one block of wood, or one box, might serve as a make-shift for a single step, more than one would not be very satisfactory. If two steps were needed, a form as in Fig. 125 should be made; or the number of steps might be continued indefinitely. The frame is a very simple one, being made of two boards, notched out on the upper side, and boards nailed to the top sides of the notches.

If the upper end should be nailed securely to the side of the platform and the lower end to the floor, the frame would serve as a combination of several steps in one, the edge of the platform being the top step. The side-pieces are the "carriages" or "stringers." Let us now for a moment suppose that a platform has been constructed at the corner of our room, a small one, 3′-0″ above the floor and 3′-0″ square; two of its edges then, join the two walls at the corner; to one of the re-

maining edges, suppose a little group of steps to be nailed. To the fourth edge of the platform let us nail the end of a slanting beam running along the wall, which shall reach to the ceiling of our room; this is called a "wall-bearer"; nail two others of exactly the same size, one to the outer edge and one in the middle. Notch them all as in the first case. If boards are placed, even loosely, in these notches, we would be able to walk all the way to the ceiling; at least, until our heads touched. Of course, this would be at a point considerably in front of where our beams are nailed to the ceiling, depending on how tall we were. If a hole could be cut through the ceiling from this point where the head touches to where the ends of the slanting beams are nailed, a little over 3'-0" wide, then we could pass right through up to the top of the floor above; our rough frame, thus, has become a simple form of stairs, of which the platform at the corner is the "landing." The "head-room" is the distance from where the head first touched the ceiling, straight down to the step below; it should not be less than 6'-6". The hole in the ceiling is the "stair-well"; its edges must be protected just as in the case of our three foot platform, by a rail. The facts which we have discovered in our simple stairs apply to any stairs and stair-cases whatever.

It should be remembered that stairs are really an inclined passage-way, so they are always found as a part of the ordinary hallway, connecting the entrance with the interior of a building, or other parts.

Tack a sheet of drawing-paper, 15"x 22", horizontally. Draw border lines ¾" from the edge all around it. ¾" from the left border line, draw a vertical line across your sheet. Near its lower end, 2" above the bottom border line, draw a horizontal line towards the right about 4". The vertical line represents the top view of the left edge of a brick wall 8" wide on top; complete the top view at ¼" scale. The horizontal line at the bottom represents the near edge of a double beam, made up of two beams each 2" wide on top and 12" deep, and fitting into the side of the brick wall, 4". Draw the top view of this double beam. 10'-7" back (or up, on the sheet) from this double beam, draw the near side of the same sized double beam, making it about 4'-6" long. Name these double beams A and B, in the order in which they have been spoken of. 3'-2" beyond

beam B, draw the near side of a second 8″ brick wall running from left to right, beginning at the left border line, and joining with the first brick wall, as in Fig. 126. The tops of the two double beams and the brick walls are supposed to be all at the same level. Represent brick walls by C and D, D being the one which runs from left to right.

The right ends of the double beams rest in the side of another 8″ brick wall, running in the same direction as C and 8′-0″ from it; but it will not be necessary to show this; it is necessary to speak of it only to show how the beams are supported. Next show a beam 3″ wide on top (6″ deep) running from beam A to beam B, and along the right edge of wall C, it being firmly secured to the double beams. 11″ to the right of it draw another beam parallel to it, 2″ wide on top and 12″ deep; 11″ to the right of this draw another one the same size; then finally, another, 11″ to the right and also 2″ thick. These four beams have their ends all secured to the sides of the two double beams.

We have completed only the top view. Looked at from the right side, we will see the end of double beam A, and 10′-7″ to the right of it, the end of double beam B, as in Fig. 127. The long horizontal lines connecting them are the long beams whose ends are joined to them. Draw the side view of A first, its left side being 7′-1″ to the right of the right hand long beam in the top view.

Its bottom line is 2″ (to scale) below the near horizontal line of A in the top view.

The front view will be only the near side of A, of course; it will be just two horizontal lines, 12″ apart at the same level as the top and bottom lines of A in the side view. Its left end should be 1′-10″ to the right of the right hand long beam fitting into A, in the plan. The right end should be about 4′-0″ from the left end. Number these views 1, 2, 3 from left to right, the top view being No. 1.

We have made a frame, like an ordinary floor frame. A few boards laid across it and nailed to it would make a floor of it. But this is not to be our use for it. We will use the drawing, line for line, but not the frame; that will be changed. Our two brick walls are to be lifted up at least ten feet; of course, this makes no difference in our drawing of them. Double beam

B will be lifted up about 8′-0″ (this, also, does not change the drawing in the top view, No. 1, at all); beam A is not changed, but remains where it is, about 8′-0″ below B. As beam B is lifted up to its new place, the four cross-beams with their ends nailed to it are lifted with it, while their bottom ends remain below, fastened to beam A.

But what will be the effect on the side view of the frame? Just this: the side (or end) view of A remains exactly as it is. The end view of B (in view No. 3) will be lifted directly up a distance of 8′-1½″. In view No. 2, B will be shown directly above A, and at the same height, as it is now shown in view No. 3. Show the four slanting beams in their proper position, four narrow vertical rectangles.

It is clear that view No. 1 remains the same although the position of the frame has much changed. Show in view No. 3 the position of the long slanting beam; it is placed so that the lower edge of it starts from the side of A, 3″ above the bottom, running from there up to meet the left side of B, ½″ above the bottom. Complete the beam, if it is 12″ wide and the ends are cut so as to make vertical lines. Our drawings, Nos. 1, 2 and 3 should appear, up to the present point, as shown in Fig. 129. One or two things may be said, in general, about the three views. First, the height of the frame (No. 2) is less than the length (No. 1); and the actual length which is shown in No. 3 is the longest of all. The long beam in No. 3 stands also for the others which are behind it, their tops and bottoms being on exactly the same lines. Note the great similarity between No. 3 and the section of a roof, with the end of the ridge pole at the top, and of the wall plate at the bottom, with the rafter running between them.

If we were to nail cross-boards to our slanting beams about a foot apart, we could easily walk from the bottom to the top or from the top down. But, we have seen on page 126, how by cutting notches in the top of the slanting beams, with one side horizontal and the other vertical, boards may be nailed to the horizontal sides, and steps thus made. That is what we wish to do with our frame, so let us begin by cutting the notches in the slanting beam in view No. 3. The cuts should be made so that the vertical sides are 7½″ and the horizontal sides, 10″, as this makes the width for the step great enough, and the

height which the foot must be lifted not too high for comfort. Begin at the bottom by cutting a horizontal line 3″ long in our slanting beam, (call this beam E), at the height of the top of beam A, then a vertical cut up to the top edge of E, as in Fig. 128. The cuts will be the same for the two other slanting beams, but not for the 3″ wall beam, which is not notched. From this last point, make another horizontal cut 10″ long, then up to top edge (this height should measure 7½″). Continue this cutting of notches until the upper end of the beam is reached. The last horizontal cut at the top should be short like the one at the bottom.

This has been a comparatively easy thing to do, and it but remains to show how these notches appear, on the front view and the top view. Imagine looking at view No. 3 from the left; what do we see? We see thirteen vertical edges in E, instead of the long straight upper surface. Show these on the three 2″ beams in view No. 2 by short horizontal lines directly opposite the edges in No. 3. In No. 1, we will see the slanting top edge of E divided into twelve equal horizontal edges, 10″ long with a 3″ edge at the bottom and one at the top, just as in No. 3. The space between double beam B and brick wall D should be crossed by 2″ beams, (12″ wide), on line with the slanting beams, only of course flat; the beam next to wall C should be only 2″ thick also. Add a fifth cross-beam to the right. These beams for the landing will not be seen in view No. 2, as they are hidden behind B. But in No. 3 they will be seen from the side, their left ends fitting against the side of B and their right against the face of wall D. In view No. 2, the 3″ wall bearer should extend only up to a point 5½″ below the top of B, as shown in the front view. In view No. 3, the upper notch of E extends about ½″ above the top of B; this will also be explained later. The brick walls C and D in No. 1 may be cross-hatched; also the front view of wall C in view No. 2 up to a height of 3′-0″ above B; and wall D in view No. 3 for a thickness of 4″ up to a height of 3′-0″ above B. The student should go over Plate 22 in his mind, from the beginning to the end. The one who can and will do this, has a great advantage over the one who does not.

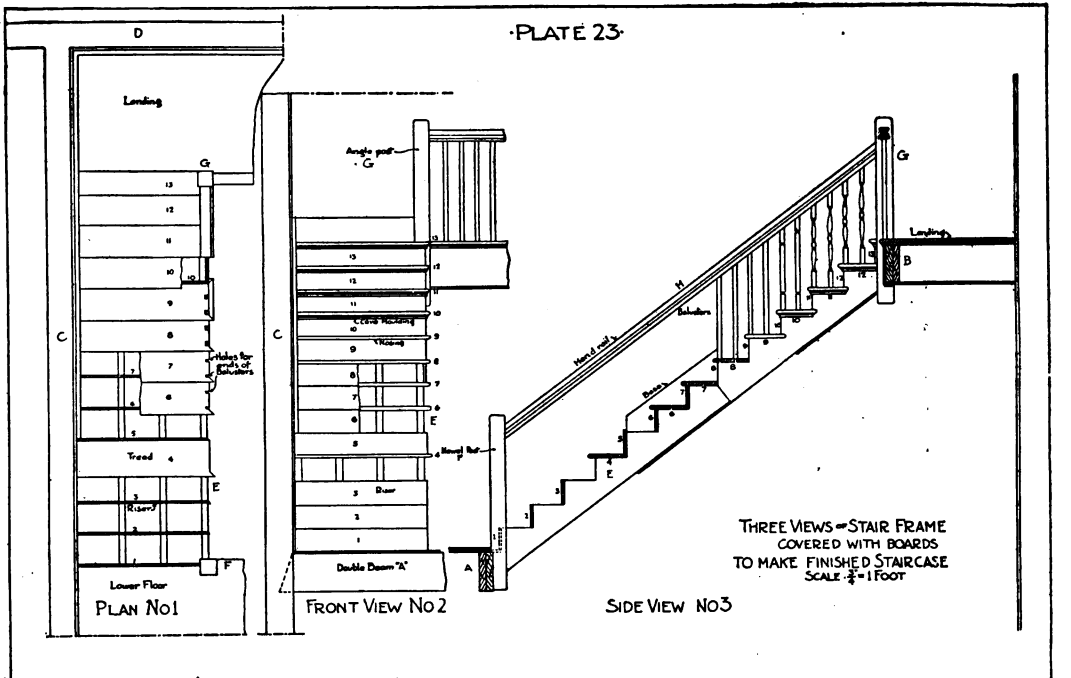
PROBLEM XXIII

(See Plate 23)

Stretch a sheet of strong, white, tracing paper over Plate 22. Tack it down securely. By means of this transparent sheet, we intend to add pieces to our structure so that the entire process of fitting stairs together may be made plain. First, let us suppose that instead of our having three views of the same staircase, we have three separate staircases, each in a different position, the frames for them being Nos. 1, 2 and 3 on Plate 22. In No. 1 draw a line all along the right hand edge of wall C, $\frac{1}{8}$" from it (scale $\frac{3}{4}$"=1 ft); this is to represent the thickness of the lathing and plaster with which the face of the wall is finished. Continue this line along the near edge of wall D. Show the same in view No. 2, by a vertical line, $\frac{1}{8}$" from the right hand side of C. Fine dots in this narrow space will indicate plaster. It will be necessary to show a vertical post 5" square, in view No. 3 at the foot of E, where E joins the double beam, A. It will rest partly on top of E and partly on A, being cut out at the bottom so that the part that does not rest on these beams, shall run by them to the bottom of A. Now for the *exact* location. From the bottom line of A, (view No. 3), draw a horizontal line $4\frac{5}{8}$" long to the right; then from this point up, vertically to a point 3'-0" above the first horizontal notch at the bottom of E; then to the left, 5"; then down to the top of A. The bottom is firmly nailed to beams A and E, being notched slightly over A as shown. Call this post, F. Do not show this in view No. 2 as it would hide too much. In No. 1 we would see just the top of it,—a 5" square, resting slightly on A ($\frac{3}{8}$") as shown in No. 3, and cut out at the bottom so that its left side is just $2\frac{1}{2}$" to the left of the right edge of E. Draw this square carefully.

Again, in No. 1, show a layer of flooring at the foot of the structure thus: 1'-4" down from the near side of A draw a horizontal broken line 4'-6" long to represent the edge of the

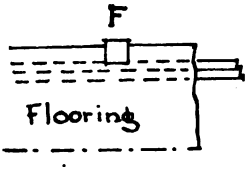
PLATE 23


D
Landing
G
C
Treads
Risers
E
F
Lower Floor
PLAN NO1
Angle post
G
Cove Moulding
Riser
Double Beam "A"
A
FRONT VIEW NO2
Hand rail
H
Balusters
Beam
Landing
B
THREE VIEWS OF STAIR FRAME
COVERED WITH BOARDS
TO MAKE FINISHED STAIRCASE
SCALE ¾ = 1 FOOT
SIDE VIEW NO3

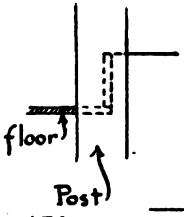
floor. Continue this up in a vertical wavy line to the same distance as the far side of post F, then draw a wavy line to the left to meet this side of the post, as in Fig. 130.

In No. 2 this layer of flooring would be shown by a $\frac{7}{8}$" thickness just on top of A, representing the front edge of the floor, and running to the line of the brick at the left; stop the plaster on top of this layer. In No. 3, the side view of this $\frac{7}{8}$" edge may be also shown on top of A, extending about a foot to the left of it, stopping at the left side of the post; the few inches of it which come behind the post up to the vertical notch in E, should be dotted. Next, a board is placed in No. 2, so that it rests on edge on top of the floor and is nailed to the vertical sides of the notches in the bottom of the stair beams. Its upper edge is on the same line as the top edge of these notches; its left edge is at the plaster line, and its right edge is $\frac{7}{8}$" beyond the right edge of E, as we saw before. In No. 3, just the end of this board will be seen behind the post (dotted vertical lines), a narrow vertical rectangle against the notch, and just the same height, as in Fig. 131. Show carefully the top view of this in No. 1, running from the plaster to the post. Number this riser in No. 2, 1. Draw also the next riser above, showing it in all three views, marked 2. Show its right end in No. 1, as in Fig. 132. Draw also the third riser in three views.

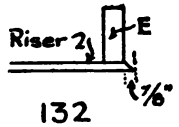
Do not draw the fourth riser, but draw the top view of the fifth in view No. 1; also the side view in No. 3. Thus far we haven't shown a single step. Let us now do so, placing a board on top of the fourth row of notches. Show this board lying flat in view No. 1. It fits against the near side of riser 5, with its left end against the plaster; its right end extends $\frac{7}{8}$" beyond the right edge of beam E, and its front edge projects $2\frac{1}{4}$" beyond the front edges of the notches. Show in view No. 3 the end of this board resting on top of the fourth horizontal notch. It will be $1\frac{1}{8}$" thick, its right edge fitting tightly against riser 5, and its left extending $2\frac{1}{4}$" beyond the vertical edge below. Show the left end rounded instead of square. Finally, show this board in place in view No. 2. To complete this tread, show a projection in No. 1 of its lower right hand corner, as in Fig. 133. This need not be shown in No. 3; and in No. 2 it may be shown by simply making the front edge $1\frac{3}{8}$" longer, keeping it rounded off.



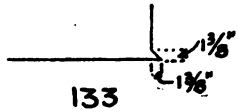
130



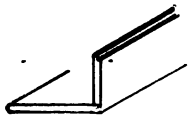
131



132

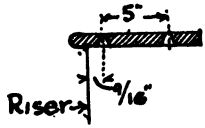


133

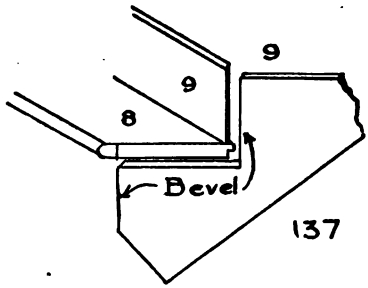


134

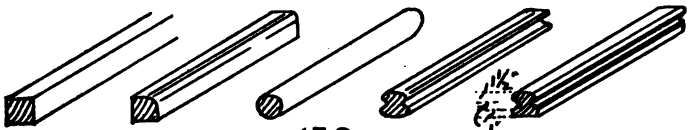
135



136



137



138

By making tongues and grooves in the edges of tread 4 and riser 5, they may be joined ever so much more tightly together, as in Fig. 134.

While we are busy covering and finishing the top of our frame, let us not forget that the under side must also be covered, but in a very simple way; there are no steps here; only a thin layer of laths and plaster; and the only view we can make of this is the side view, or edge, in No. 3. From the lower right hand corner of riser 5, view No. 3, draw a faint line across E, at right angles to its slanting edge; from the same corner of what would be riser 8, draw another similar line, but not faint. Trace the under line of E between these two lines; ⅛″ below this draw another line parallel to it; connect their ends. The space between these lines is occupied by plaster; all the rest of the length is covered by plaster, but this is all we will show. From the upper right hand corner of riser 5, in this same view, draw a vertical line up 5″, then from its upper end, draw a line up to the right, parallel to the lower edge of E, to a point that would be directly over the face of riser 8. This is the top edge of a board which is nailed to the wall and runs all the way up from top to bottom; but this is all we will show, now. On view No. 2, show the front view of this board, 1⅛″ thick, its ends projected across from No. 3. Show the top view of the same on No. 1, see Plate 23. Omit tread 5. Draw left half of riser 6 in view No. 2. Draw on view No. 1 the right half of tread 6, showing two holes in its right end, as in Fig. 135. These holes are narrow on top, and wide at the bottom; the top being a rectangle 1″ long by ½″ wide; the bottom being 1″ square. The center of the first hole is 9/16″ from the face of riser 6; the second is 5″ back from it. The two holes, or mortises, in the end of tread 7 will be spaced in just the same way, so that the distances between all four from front to rear in view No. 3, will be exactly the same. In view No. 3 these holes at the end of tread 6 appear as in Fig 136. Draw view of riser 6 in No. 3; also in No. 2, showing only the left half, extending to the right side of the wall string. Show in view No. 1 the right end of tread 7, exactly the same as tread 6; also left end of riser 7. Show side, or end views of these on No. 3; also on No. 2.

Draw in view No. 1, the board 1⅛″ thick which runs along the

plaster of wall C all the way to the line of the plaster along wall D. This is shown merely by a line parallel to the plaster line, 1½" from it; show it also in No. 2 by a vertical line 1½" from the plaster line running up to a height of 9¾" above the top of beam B. Do not show this on No. 3. In view No. 1, show all of tread 8 running from this wall string to the right edge; the only difference in the right end will be that the two holes will be hidden by two small square posts placed right on top of them, 1½" square, their bottom ends being cut out in the form of dove tails, or wedges, to hold them fast in the holes. These squares are placed so that the near edge of the front one is exactly over the face of the riser below, and the right edge exactly over the right edge of the tread. The center of the second square will be just 5" back from this one. To show that the posts are in position, cross-hatch these squares. On view No. 3 show the end of tread 8 running to what would be the face of riser 9; it will be exactly the same as the end views of treads 6 and 7 except that the square posts will be exactly over the holes. Make these posts about 2'-0" high; their exact height will be given later. Show the entire front view of tread 8 in No. 2.

Next, a finished board is to be laid flat against the face of beam E in view No. 3; the bottom edge of this board is exactly on line with the bottom edge of the plaster, and starts from where the plaster was stopped below the end of tread 8, and runs to the top. The lower end runs from the lower right hand corner of tread 7 in No. 3 down to the bottom plaster line at right angles to it. From this same corner of the tread it goes up vertically to the under side of tread 8. This vertical edge is bevelled off to fit the bevelled end of the riser, as in Fig. 137, the horizontal edge fitting directly under the projecting edge of the tread. The end of the riser is thus hid. Show the front view of it between the ends of treads 7 and 8 on view No. 2, but not on view No. 1.

We have not called on the post, F, at the bottom of our staircase to do any work yet, but we will do so in a very few moments. First, however, show at the top (view No. 3) a second 5" post, G, just where beam E meets beam B on Plate 22. Draw it on No. 3, so that its left side is 2¾" from the left side of B; so that its top is 3'-1¾" above the top of B, and its

lower end extends down 7″ below the under side of B. For the present, it may be left perfectly square. Next, show a square beam, H, 3½″ square, running all the way up from post F to post G. To find how high above the steps it should be, measure from the top of any one of the treads (view No. 3) at the point just over the face of the riser below, a distance of 2′-6″ up. Make a point here; then draw a line through this point parallel to the under edge of beam E. This line, running from post to post, represents the top line of the 3½″ beam; draw a second slanting line 3½″ below this, measured at right angles to its length, for the under line of the beam. The little square posts at the end of tread 8 should run up to the under side of this beam and be nailed to it.

In regard to beam H, as we know, it is not merely to prevent persons falling over the edge, but to be used as a rail to be grasped by the hand to pull the body up. Then, certainly, a wide square beam is not the pleasantest rail that we can think of for this purpose. Figure 138 represents a collection of rails the one at the left end being a plain square one; the next figure shows its two upper corners rounded off and smoothed; the next, one with all the corners rounded so as to make the beam entirely round like a pipe; the next is the same as the second but with a groove in its side for the fingers; the next is practically the same, though with the bottom part square.

Draw two lines along the rail, one 1½″ below the top, the other 1″ below that, as shown on the last figure.

In regard to the two posts, the one at the bottom, or newel, and the one at the top, or angle post, it is clear, again, that these might be left perfectly square with sharp corners and edges, and still do their work. Yet they will be much better for being rounded off, especially at the top of F, and at the top and bottom of G. There is an almost unlimited variety of these posts, so that one person could see but a very few of them in a life-time. But we know some facts about them all, without seeing them; for instance, that they are tall, though not so much so as a person; that most of them have a "head" at the top, and widen out at the bottom, the part of the length between being the slenderest. The row of drawings in Fig. 139 shows how a simple wooden beam placed on end as a post, may be so added to and dressed up as to develop into a

regular stair-post. It will instantly be seen in the second one that the post is the body; a block is used for the head, and another block for the foot.

The process is very simple; here are six figures; the first is a single post; the second is the same post, with a block on top of it, and a larger at the foot; in the third each block is divided into two and three parts; in the fourth a slight variation is shown; in the fifth the lower of the three divisions at the top is rounded off; in the bottom block an additional division is made; in the last, an extra division is made in the top block, and the second division is rounded off to the form of the double curve; a small square block, like a cap is shown on top; the bottom block is also finally divided into four parts, the second one being "moulded" into a double curve. The faces of the post are hollowed in the middle to make a "panel."

Now to the finishing of our treads, risers, balusters, etc. First, draw on view No. 1 the near edge of tread 9; finish the right end just as in tread 8, showing the little square posts, keeping them spaced exactly 5″ apart on centers. Draw the near edge of tread 10, from the wall over to the right, stopping it right off 6″ before you reach the left of beam E, and continuing the right end of riser 10 the rest of the distance, finishing it as in riser 2 and 3. By leaving this opening under the right end of tread 10, we can show not only how the finished board which is nailed to the face of beam E, has one of its vertical edges joined to the end of a riser, but also how instead of leaving the ends of the treads jagged as in 6, 7 and 8, a piece of wood is fitted neatly into this end, thus covering the holes and finishing the tread. Fig. 140 shows clearly how this is done; the top view would appear as in Fig. 141.

In view No. 3, the end moulding of tread 9 is shown as in Fig. 142. Show the two square balusters like those on tread 8. In view No. 2, show riser 9 complete as in risers 1, 2, and 3; show tread 9 also complete.

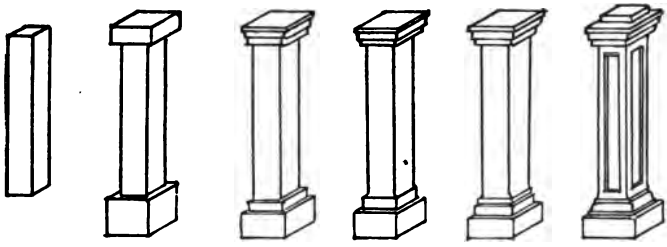
In view No. 1, tread 10 has been shown with an opening in its right end; however, we may show the right end in view No. 3 as though it were whole, making it the same as the end view of tread 9; show two balusters also on this tread. Now, as we have said, the front edge of the tread, which extends beyond the face of the riser is rounded off smooth to make walk-

ing up the stairs easier. Well, along the crack between this nosing and the riser beneath it, a little strip of wood is nailed, which is moulded neatly, thus making a neat finish to the steps. The shape of the piece is shown in Fig. 143. This moulding also follows the nosing around the end.

Draw this moulding in view No. 3 under the end of tread 10 as shown in Fig. 142. Draw it also under the nosing in view No. 2.

The balusters on tread 10 are to be rounded, or "turned," in the following manner: the bottom 5″ of each will be left square. Draw on view No. 3 a short horizontal line across each, 5″ above the bottom. 4″ below the top of the left side of the left baluster, draw also a short horizontal line; also on the other baluster at this same distance below the rail. The space between these square ends is to be rounded off or turned just like a pipe. The second one is to have additional grooves turned in it, as in Fig. 144. Finish the outer ends of treads 11 and 12 like tread 10.

Only the left hand corner of tread 13 can be seen in view No. 3 on account of the angle post. Draw faintly the outline of two balusters on treads 11 and 12, leaving square tops and bottoms as with those on tread 10. Draw, in view No. 1, the near edge of tread 11. Then find a point on the near line of post G, (view No. 1), $1\frac{3}{4}$″ to the left of the center of it; also one $1\frac{3}{4}$″ to the right of the center; from these two points draw vertical lines down to meet the near line of tread 11; they represent the top view of the hand rail. Draw also treads 11 and 12 showing their ends projecting a slight distance beyond the edge of the hand rail. The front edge of tread 13 is really the edge of the landing floor, but it is shown just the same as a tread. The rear edge of tread 13 should be on line with the rear line of post G in view No. 1 on the same level as the landing floor. The rest of the landing floor will be ordinary floor boards which need not be shown. Complete your drawing of steps (treads, risers, mouldings) 11, 12 and 13 on view No. 2. Draw also the front view of the top post, its ends being on exactly the same height as in view No. 3. 8″ above the top of tread 13, in view No. 2, draw the top line of the baseboard along wall D. Draw the top view of this along the wall in view No. 1. We have seen that double beam B in view No.



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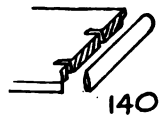

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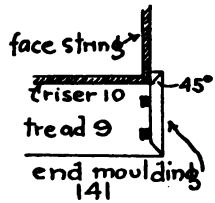

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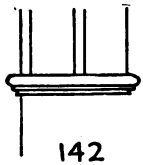

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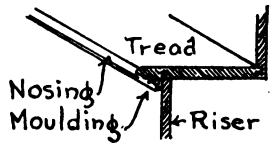

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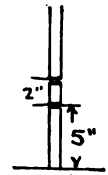

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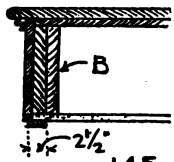

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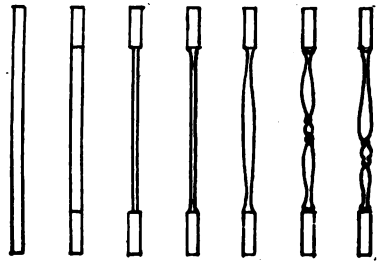


146.

1 is continued some distance to the right; but, as we have not room enough, only about a foot's length of it is shown to the right of post G. From a point on the right side of post G, $\frac{3}{4}$" above the lower right hand corner, draw a horizontal line to the right, 1'-0" long; this represents the near edge of the landing floor to the right of the stairway. From the end of the line, draw upward a wavy line until it meets the right end of wall D; this is the broken edge of the floor. The side view of this edge, of course, is shown on No. 3, by a horizontal line, $\frac{7}{8}$" above B, and along the top of the short beams running from B to wall D. $\frac{7}{8}$" above this line is another horizontal line, which indicates the top surface of the finished flooring. The left end of this top layer stops within $\frac{3}{4}$" of the left side of post G and is rounded off just like the nosing of the treads. A $\frac{7}{8}$" layer is also shown under the landing beams in No. 3 for the laths and plaster; its left end stops at the left edge of beam B; unless there is a little strip of wood $\frac{7}{8}$" thick nailed to this under edge of B ("ground") for the plaster to stop against. The left edge of the rough beam, B, is also covered by a $\frac{7}{8}$" layer which, in this case, is a finished board, running from the under side of the finished flooring to the bottom plaster line; by means of these various layers, all the rough construction work of the landing is hidden. A moulding should be shown under the edge of the flooring at post G. Where the plaster and this finish face of B ("fascia") meet, a small strip of wood should be nailed to close up the crack between them, as in Fig. 145.

The front view of this landing (No. 2) will be, of course, the face of this board, and at the top, the edge of the flooring and the moulding; at the bottom, the edge of the $2\frac{1}{2}$" strip, $\frac{7}{8}$" thick, will be seen. The length of this from the post to the right should be 2'-0". Show $1\frac{1}{8}$" square balusters, 5" apart on centers, the space between the first one and the post being $4\frac{1}{2}$". Show the hand rail 3'-0" high, with lines for mouldings as in No. 3. The end view of this rail, show in No. 3 copying form from Fig. 138. Show, also, the balusters in this view. In view No. 1, a second horizontal line $3\frac{1}{2}$" from the landing edge line should be drawn to represent the inner edge of the top of the rail.

By turning to Fig. 138, we can see at a glance how out of a

square timber a richly moulded hand-rail is made, developing from the square piece to the rounded and, finally, the moulded rail. Again, in Fig. 139, a 5″ square beam is made to develope into a moulded newel post. Let us now see in Fig. 146 how a smaller square wooden strip about 2′-6″ long becomes a baluster.

The first example at the left represents a square post a little over an inch thick. The second represents the same post with the ends still square, but the part between them made round; the third the same, with the body still round but much thinner. The fourth is exactly the same as the third, except that the ends of the middle part are made to flare out. In the fifth the middle part of the body is shown swelling out at the middle. The sixth shows two of these same swelled forms of less than half the size of the former, and separated by a sort of bead in the middle. At each end is a small ring, or "fillet." The last is the same except that the upper half is longer than the lower. Let us draw in the sixth for the last four balusters at the top of our stairs in view No. 3.

Finally, as there are 13 separate risers and 13 separate treads, we must number them from the bottom up to the top. Beginning on view No. 1, write the figure 1 very small just above the first riser, and half way between post F and the plaster on the wall; do the same for risers 2, 3, 5, 6, 7 and 10. In this same view, write the number on tread 4, ¾″ (actual) from the right edge of the tread; write the same for treads 6, 7, 8, 9, 10, 11, 12, 13. In view No. 2 letter the numbers of all the risers except 4. Letter the numbers of treads 4, 6, 7, 8, 9, 10, 11, 12, 13 just to the right of their right ends. In view No. 3 letter the numbers of all the risers but 4, just at the left of their middle points, and the numbers of the treads just under their middle points. At the top of the sheet, 7/16″ down from the border line, draw "Plate 23," the letters being ¼″ high. Draw title carefully, as shown in Plate 23, making the width of letters 3/16″; also the spaces between, with the exception of the last space and row of letters which are ⅛″.

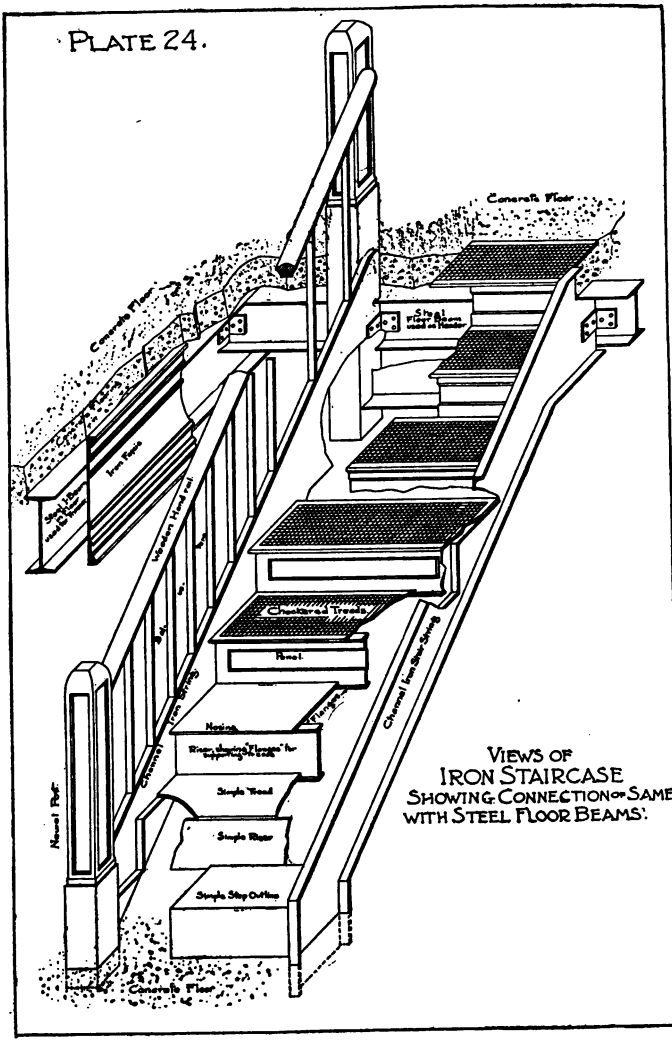
Having drawn this plate all in carefully in India ink, and then removed all signs of dirt, cut off on the outside margin line, and it is finished.

PROBLEM XXIV

(See Plate 24)

The drawing of Plate 24 is not insisted upon, but enlarging the drawing four times, or to about 1½" scale, would be of the greatest benefit to the student in the clear understanding of fire-proof stair-construction. Note how similar in every way this stair-case is to the one we have just finished; the treads, to be sure, are of solid iron about ⅝" thick, while the risers are not over ⅜" thick. The posts, though of the same outward shape, are only a shell enclosing a square, hollow space. The stringers, or main supporting beams are practically the same width as the wooden ones were, but are really thin iron plates, with their top and bottom edges bent over, to form little shelves (flanges) 1½" wide. The upper ends, are joined to the sides of the steel floor beam in almost the same way in which the wooden ones were, except that the nails in the present case are bolts, or rivets. The hand rail is really what is called a little T-iron, 1¼" on a side, and upside down, the ends of it, of course, being bolted to the posts in very much the same way as the stringers are bolted to the floor beam. The top upright post is secured to the floor beam in the same way, the lower one, however, being merely built into the concrete of the lower floor. On the left of the drawing, the iron fascia is put on over the big floor beam, and in front of the rough edge of the concrete floor, to cover it up, and thus to give a fine finish.

PLATE 24.



VIEWS OF
IRON STAIRCASE
SHOWING CONNECTION OF SAME
WITH STEEL FLOOR BEAMS.

PROBLEM XXV

(See Plate 25)

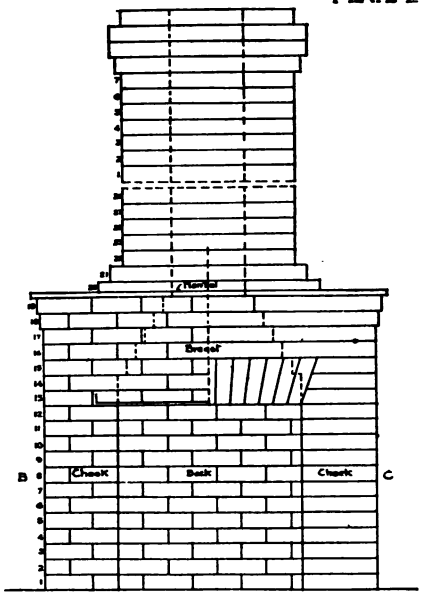
In the middle of a cement floor of a long one-story brick building, which is open to the roof, let us imagine a single layer of brick laid, four or five feet square, and just the height of an ordinary brick course, as in Fig. 147.

This has very little resemblance to a fireplace, though it has some of the qualities of one; such as being fireproof and having a "place" or definite location. Let the three sides of an oblong about 2'-6" long and 1'-6" deep, be drawn on top of this, with a piece of chalk, the front side being left off, and a low wall built around them, as in Fig. 148. A fire burning inside this space would be kept from scattering by the sides. But not so with the smoke. The good of the fire, which is its heat, would be obtained, but so would the unpleasant part, or smoke. Now, suppose a little hood of sheet metal to be built directly over the opening, as in Fig. 149, resting on small iron rods, as shown, and with an opening in the top to which a pipe is attached which leads up through the roof. It is evident that there is now much less likelihood of the smoke being scattered; if the little brick walls are carried right up to the hood, practically all the smoke will be carried up by the heated air through the opening and pipe into the outer air, as in Fig. 150.

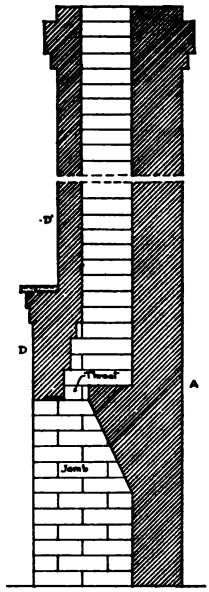
If the hood and pipe, instead of being sheet metal are made of brick, we will have the ordinary fireplace as in Fig. 151, the brick at the front of the opening being supported on an iron beam, or lintel, and being corbelled inward so as to narrow the opening up gradually to the size of the small smoke flue where the chimney begins. The method of drawing such a fireplace, flue and chimney is accurately brought out in the problem shown on Plate 25.

The ordinary size of a fireplace opening is 2'-6" square at the front, as in Fig. 151. The wall at the back is generally 8" thick, and the side walls 12". The distance which the opening

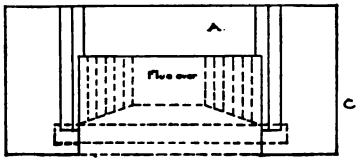
PLATE 25



No 2 FRONT VIEW



No 3 SIDE VIEW



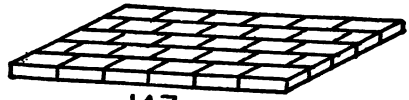
No 1 PLAN

BRICKWORK
ARRANGED SO AS TO FORM
AN OPENING AT THE
FRONT AND TOP FOR
FIRE PLACE AND SMOKE
FLUE.
Scale 1½" = 1 Foot

goes back, or the depth, is, on the average, 16″. As a chimney is a heavy load, special foundations must be made for it, just as for any other brick wall.

Now, how are we going to join a big opening which is 2′-6″ wide and high and 16″ deep, with the bottom of a hole running up through the chimney only 8″ square? Let this be the problem for our next and last plate.

Tack a sheet of paper 15″x 22″ in a vertical position on the drawing board. Draw the usual border lines. Draw a horizontal rectangle 6¾″ long by 1″ wide, so that it is 5-9/16″ above the bottom border line and 1″ from the left hand border line. 1½″ above this draw a narrow horizontal rectangle exactly the same length and 5/16″ wide; number the last view, 2; the first, 1. Directly opposite No. 2 to the right, draw a short horizontal rectangle the same height as No. 2 and 1″ long, so that its right side is ¾″ from the right border line; mark it No. 3. The three rectangles should appear as shown in Fig. 152, and represent an object of the shape shown in Fig. 153. These three views are the top (No. 1), front (No. 2), and side view (No. 3) of a single course of brick stretchers 8″ thick, being two rows; the scale is 1½″ to the foot. Draw the vertical joints on view No. 2. On top of this single course are placed eighteen more courses of the same size, breaking joints; show these on view No. 2, marking the number of each at the left of the course. Show these also on view No. 3 without the joints. View No. 1 remains as it is. Then show on view No. 2 course No. 20, making it 9″ shorter at each end than the courses below; course No. 21, showing it 2″ shorter at each end than No. 20; course No. 22, 2″ shorter at each end than No. 21; the side view for these three courses is no different from all the others. These little steps or "offsets," may also be shown on view No. 1. Call this wall, A. Next, a short brick wall is placed flat against the front face, at its left end; call this wall, B. It is fourteen courses high, 12″ wide on the front, and is 8″ deep, as in Fig. 154. Show carefully on all three views. Courses Nos. 15, 16, 17, 18, and 19 on top of the pier have all the same depth, 8″, and their left edges are all in the same vertical line, but their right edges, beginning with course No. 15, project 1½″ beyond the edge below them. Course No. 20 projects 1½″ to the right of No. 19, but is only 12″ long on the front; No. 21 is 10″ on the



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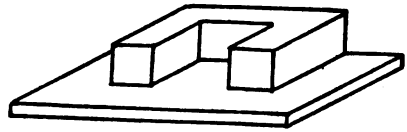

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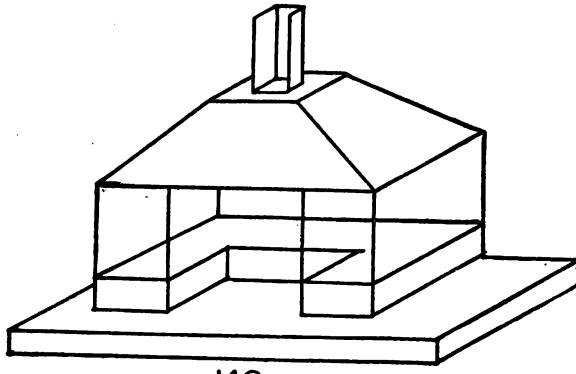


149

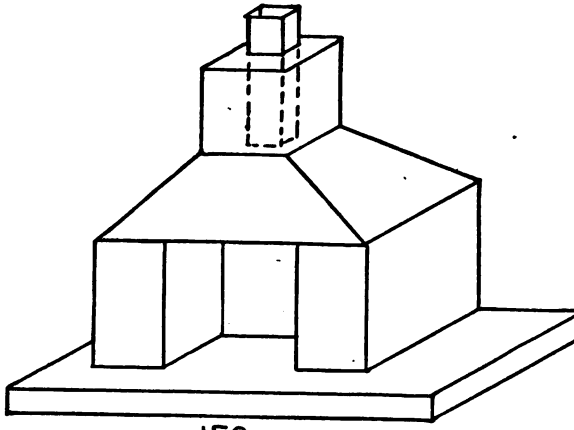
front, with its right edge directly over the right edge of No. 20; No. 22 is 8″ wide, with its right edge over the right edge of Nos. 21 and 20. Courses Nos. 23, 24, 25 and 26 above this are the same as No. 22. On view No. 1, these edges will be shown in dotted lines. On the side view, these projections look no different than if they were perfectly straight.

Now, draw a pier, C, in exactly the same way as B, but at the *right* end of A, and with the slanting ("corbelled") edge on its left side at the top. Do not show this on view No. 3, as it will hide what we have done already; show on Nos. 1 and 2. The view of walls A, B and C at the top is shown as in Fig. 155. The opening between the three 8″ walls at the top is, of course, the smoke flue for a chimney, 12″ wide on the front and 8″ deep; this is very often lined by a terra cotta pipe, or "flue lining." The slanting space between the top of the fireplace and the chimney flue is called the "hood." The large space below forms part of the fireplace.

Above the twelfth course, the front of this opening must be enclosed by another wall, as it is now open. In order to do this, we will build another 8″ pier, twelve courses high, right in front of each pier, B and C. Show these only on views Nos. 1 and 3, as they could not be seen on view No. 2. Call these B′ and C′, as in Fig. 156.

In order to start the wall over the top of the fireplace opening, we must span it with something; a strong iron bar is generally used. Show a bar on view No. 2, ½″ thick and resting 4″ on pier B′ and C′; it is 3″ wide, but does not set out at the extreme front of the piers, but 2″ back. This must be shown on view No. 3. It may also be shown in dotted lines in No. 1; show only the left half of it in view No. 2.

Place another full sized course, (No. 13), on top of pier B′ in view No. 2; this course is 8″ deep, just as the pier is, but the part which shall rest on the iron bar is only 5″ deep, (that is, from front to rear), resting on top of the bar, with its front face flush with front face of pier B′. Course No. 14 on pier B′ is the same size as No. 13, and from the edge of the pier across the iron bar, it is 5″ deep, as in the last case. Course No. 15 on the pier projects 1½″ to the right just as it does on pier B, and from this edge across the bar, it is 6″ wide, its inside edge thus projecting 1″ beyond the edge of No. 14. Show this on



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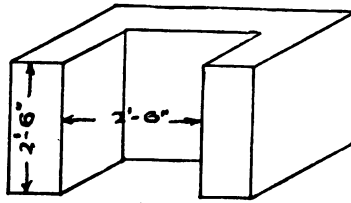

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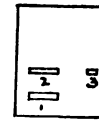

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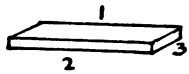

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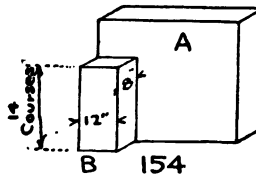


154

view No. 3. Course No. 16 on the pier is the same as on pier B, the part extending across the opening being 6″ wide, the same as No. 15. Course No. 17 across the opening projects 1″ beyond the inner edge of No. 16. Show it on view No. 3. Course No. 18 projects 1″ again beyond the inner edge of No. 17, and No. 19 is the same as No. 18. In the side view, the drawing of the cross wall is shown as in Fig. 157. Show only on the left half of the opening. Call this wall over the opening, D, up to the shelf; above this D′.

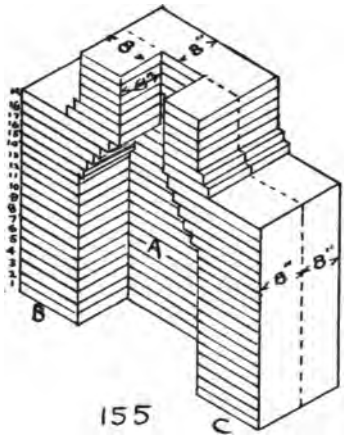
It will be seen that the front of the opening is closed in for only seven courses above the top of the fireplace. From the nineteenth course up to the twenty-sixth, will be placed in front of the flue opening a 4″ wall as well as the brick sides to it. This 4″ wall fits tightly to walls B and C, thus closing the flue opening. Show this on view No. 3. As the corbelling for piers B and B′ will be hidden behind this front wall, the stepped lines should be shown dotted, in order to show just where the side of the hood is; also dot the side of the flue. Show course No. 18 on view No. 3 projecting ½″ to the left of the face of No. 17; and course No. 19, projecting ½″ to the left of No. 18. Then on top of the shelf which No. 19 makes, show a slab of marble 1″ thick, projecting 1″ to the left of 19; show this also on view No. 2. A corner of these top courses, on view No. 2 appears as in Fig. 158.

Make the top of course No. 26 on views Nos. 2 and 3 a dotted line. The entire thickness of walls D and D′ on view No. 3 should be cross-hatched, to show that they are in section; so should the entire thickness of wall A on view No. 3.

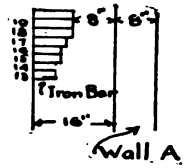
Leaving a space of ⅛″ (actual) above course No. 26, on views Nos. 2 and 3 draw another horizontal dotted line, and then seven courses more of brick above this; make the eighth course project 1″ beyond the seventh, and the ninth and tenth, 1″ beyond the eighth. Draw, finally, the eleventh course on line with the seventh. Only the top eleven courses of the chimney are shown.

The front faces of walls B′ and C′, are the "cheeks"; the front of walls D and D′, the "breast"; the inner faces of B, B′ and C, C′ are the "jambs"; the front face of A, the "back," the marble slab on top of B′ and C′, the "mantel shelf."

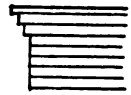
As our structure stands, the fireplace opening is 2′-6″ wide; 2′-6″ plus the height of the hood, high, and up to the iron



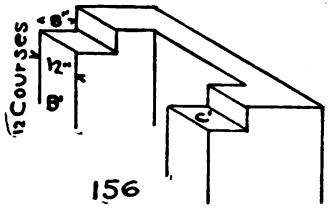
155



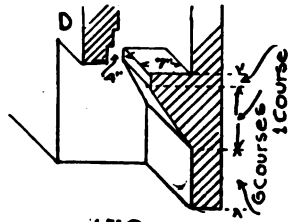
157



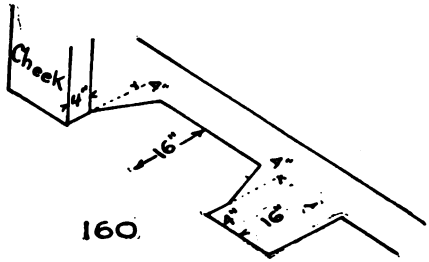
158



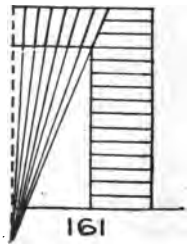
156



159



160



161

bar, 16″ deep; from there on the depth of the hood decreasing from 11″ to 8″. That is, the big opening at the top is 11″ deep by 2′-6″ wide. This is too large, as it not only is a way of escape for a great amount of heat, but it gives an opportunity for cold draughts to sweep down, in the case of a high wind. Now, if wall A could be built out on a line with the top of the fireplace a distance of 7″ toward the front, leaving a narrow space for the flames and smoke to rush up through, and thus providing a shelf at the back, to prevent the cold blasts from coming into the room, our fireplace will be perfected. If a damper is used, it rests practically on top of the shelf and can be moved out over the edge so as to close the 4″ opening. Show this shelf carefully in view No. 3, cross-hatching the edge, as shown in Fig. 159. The inside faces of the fireplace are generally lined either with sheet iron, or a layer of fire brick so as to make them proof against excessive heat. The jambs, too, very often, instead of going straight back, go back straight for a distance of 4″ then slant in toward each other to the back another 4″, as in Fig. 160.

There yet remains to be done, the right half of wall D, over the top of the opening. Show here, on view No. 2, 6½ bricks of a flat arch, as in Fig. 161. To find the slant of each brick, stick a pin in your drawing in the middle line through the fireplace, and 1½″ (actual) below its bottom line. Divide the right half of the top line of the fireplace into thirteen equal parts; then beginning at the right end, each two will represent the lower end of a brick placed on end and slightly slanting. Place the edge of a triangle on the pin, and draw slanting lines through the points as shown in Fig. 157.

CONCLUSION

In this book, we have learned how to put pieces together, on paper, to make the various parts of buildings; we have learned to draw blocks (bricks, stone, terra cotta) and boards, fitting them accurately together, edge to edge and face to face, as in any puzzle, to make the huge boxes, called buildings.

And, now, having made floors, we are ready to "plan" them so that they may be suited to any need that we may have for them; that they may be made of the proper shape, size and strength with walls crossing them at various points, dividing them into rooms, halls, closets, etc. And the same of walls—we are ready to make them wherever needed and in connection with other walls; to put windows and doors in them, to beautify them, and to arrange their parts in such a way as to produce a "Style."

THE END.